Report of the Committee on

TRAINING IN HEALTH & SAFETY

to the

Authority Committee on Health and Safety

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

February 1960

LONDON

HER MAJESTY'S STATIONERY OFFICE

1960

FOREWORD BY THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY

1. The Committee on Training in Health and Safety was set up under the chairmanship of Sir Douglas Veale by the Authority in consequence of recommendations in the Report of Sir Alexander Fleck's Committee on The Organisation for Control of Health and Safety in the United Kingdom Atomic Energy Authority (Cmnd. 342). These were that the Authority "as the vanguard of the nation's effort, should assume responsibility for building up the national supply of . . health and safety specialists" and "should establish a national training centre for health physics and nuclear safety staff".

2. The Authority are grateful to Sir Douglas Veale and the members of his Committee for the effort they have devoted to their task during the last twenty months.

3. The Committee's study of these problems on a national scale led them to consider matters outside the Authority's competence. The Authority are grateful for the co-operation given to the Committee by government departments and many other organisations.

4. The Committee's recommendations are now being studied. Those which are not within the Authority's responsibilities are being referred to the appropriate government departments for consideration.

April, 1960.

3, Cornmarket Street,

OXFORD.

25th February, 1960

Sir,

The Committee on Training in Health and Safety have now completed the work which was remitted to them by the Authority as a result of the findings of the Fleck Committee on the Organisation for Control of Health and Safety in the United Kingdom Atomic Energy Authority, and our final report is enclosed.

We have already made two interim reports, on postgraduate training and background training respectively. The Authority authorised us to carry out certain arrangements which we proposed, and these are described in Chapters VI and VII.

We have interpreted our terms of reference freely; we have included in our survey not only the need for training specialist radiological health and safety staff at various levels, but also the need for education and information over a very wide field. We have in addition made recommendations in Chapter IV as to the means whereby, in our view, the services of highly trained specialists can most effectively be provided.

I am, Sir,

Your Obedient Servant,

(*signed*) DOUGLAS VEALE

The Secretary,
Authority Committee on Health and Safety,
United Kingdom Atomic Energy Authority,
11, *Charles II Street,*
*London, S.W.*1.

ATOMIC ENERGY AUTHORITY COMMITTEE ON HEALTH AND SAFETY

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SIR WILLIAM PENNEY, K.B.E., F.R.S.

A. S. MCLEAN

Secretary: I. G. K. WILLIAMS

COMMITTEE APPOINTED BY THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY TO CONSIDER TRAINING IN HEALTH AND SAFETY AND TO REPORT TO THE AUTHORITY COMMITTEE ON HEALTH AND SAFETY

SIR DOUGLAS VEALE, C.B.E. (*Chairman*). Formerly Registrar of the University of Oxford

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PROFESSOR B. W. WINDEYER. Professor of Radiology (Therapeutic) in the University of London. Dean of The Middlesex Hospital Medical School. Consultant adviser to the Minister of Health. A member of the Fleck Committee

J. E. JOHNSTON. (Secretary)

L. M. ARNOLD. (Assistant Secretary from 1st January, 1959)

J. THEWLIS acted as Secretary from September to December, 1958.

* From 1st October, 1958. C. A. Adams, now Chief Nuclear Health and Safety Officer of the Central Electricity Generating Board, was a member until he resigned from the Atomic Energy Authority on 30th September, 1958.

CONTENTS

CHAPTER I

INTRODUCTION

1. Before the first chain-reacting pile was developed radiation hazards concerned relatively few people, and these were mainly engaged in the use of x-rays and radium in medicine. However, the dangers of over-exposure to radiation had long been recognised, and by the late nineteen twenties various national and international bodies had made recommendations on precautions and safe procedures. In the United Kingdom there were specialists with first-hand experience of radiation protection procedures, and the effects of ionising radiations were being studied.

2. The situation was radically changed by the development of the chain-reacting pile in 1942 and the subsequent production of very large quantities of radioactive fission products as work on atomic energy developed. Many more people became involved in operations incurring possible exposure to radiation. Thus a more extensive field of work developed to safeguard the health and well-being of the persons involved.

3. When, in 1946, an atomic energy organization was set up within the Ministry of Supply, it was necessary to build up the fundamental knowledge on which to base practical procedures. In doing this, invaluable help was obtained from those who had already studied such subjects as the effect of ionising radiations on biological systems, the measurement of radiation, and radiation protection[1]. They were assisted by specialists in relevant branches of medicine, science and engineering who were brought into this new field. Thus, a small group with highly specialised knowledge of protection against radiation was established in the Ministry of Supply and, later, the United Kingdom Atomic Energy Authority. This group was faced with a wide variety of novel protection problems presented by the rapid growth of all aspects of the use of atomic energy.

4. The subsequent rapid progress in the exploitation of atomic energy, including the increasing use of ionising radiations and of radioisotopes in research, medicine, agriculture and industry, and the widespread public concern about possible long term radiation effects, have emphasised the need for specialised knowledge on radiological health and safety. Thus the burdens on the small number of specialists in this field have steadily increased. In particular the staff of the Atomic Energy Authority have been called on to provide help in many forms to national and international bodies, government departments, oversea countries embarking on or at an early stage in their nuclear energy programmes, local authorities, and users of radioactive materials; and have often been called out to deal with incidents involving loss of, or accidents to, radioactive materials.

5. Ionising radiations, unlike many hazards, are not immediately recognisable by any of the human senses. Moreover, while severe over-irradiation may

[1] Some of these, including two members of the present Committee, had, in fact, gained first hand experience by working in the war-time atomic energy projects in North America.

soon lead to obvious effects such as skin burns or changes in the number of blood cells, other effects might not become evident for many years; and many generations would have to elapse before the full effects of excessive irradiation of a whole population became manifest. It is therefore of particular importance that there should be an effective national supervision of radiological health and safety.

Terms of reference

6. Investigation of the accident at Windscale No. 1 Pile on 10th October, 1957, first drew public attention to the national shortage of trained radiological health and safety specialists. The Committee appointed by the Prime Minister, under the chairmanship of Sir Alexander Fleck, emphasised in their Report on the Organisation for Control of Health and Safety in the United Kingdom Atomic Energy Authority that they regarded this as one of the most important points emerging from their review.[1] The Report called for more comprehensive instruction in radiological health and safety, and for the Atomic Energy Authority, the electricity authorities and industry to be reinforced by expert health and safety staff at all levels. The Report also noted that there was "an urgent need for education in radiological problems over a wide field of industry and the public service".[2]

7. Having emphasised that this was "a matter of urgent national importance", the Fleck Committee recommended that the Authority should take the lead in building up the national supply of health and safety specialists. Accordingly, the Authority appointed us with the following terms of reference:—

> "Having regard to the Report of Sir Alexander Fleck's Health and Safety Committee (Cmnd. 342) to consider what steps should be taken by the Authority:—
>
> (a) to provide the specialist health and safety staff required for employment by the Authority;
>
> (b) to build up the supply of health and safety specialists commensurate with the future needs of the nation as a whole; and
>
> (c) to establish a national training centre for health physics and nuclear safety staff;
>
> and to report to the Authority Committee on Health and Safety".

8. We believe that we have acted in the spirit of the Fleck recommendations by interpreting our terms of reference broadly. We have included in our review not only the training of health and safety specialists but also the need for education in radiological problems over a wide field of industry and the public service.

Procedure

9. We divided our work among six subcommittees. To four of these subcommittees we assigned the task of assessing the demand for training in

[1] Cmnd. 342 (H.M.S.O. 1958)—paragraph 93.
[2] Ibid, paragraphs 96 and 98.

radiological health and safety; the other two were asked to work out courses for training at various levels, and to consider where and how such courses might be provided.

10. We have collected a good deal of information, made a number of instructive visits, and taken evidence, written and oral, from many organisations and individuals. To many the problems were comparatively new and unfamiliar. A list of our various sources of evidence is given in Appendix A and we should like to express our appreciation of the valuable help and co-operation we have received.

11. We have met in full committee nineteen times and there have been twenty nine subcommittee meetings.

Stages of the work of the committee

12. Our work fell into three main stages:

(a) to collect comprehensive information on:—

 (i) those for whom training was required, their duties and their probable numbers; and

 (ii) the courses of training already provided, and the courses likely to be needed to meet the demand at different levels;

(b) to relate our assessment of the demand for training to the types of courses proposed;

(c) to consider where and how the various kinds of courses could be provided; whether the demand could be met from existing training resources; and (if not) what special provision ought to be made.

13. Thus we have examined the functions in the field of radiological protection of the public service, of those engaged in teaching and research, and of those in a wide range of industry. We have had to consider levels of training ranging from background courses lasting only a few days to postgraduate courses lasting up to three years. We have found it desirable to make two interim reports—one on postgraduate training and one on background training—on which action has already been taken. An account of these reports, and the action taken on them, is given in Chapters VI and VII. The considerable amount of business which has arisen from these interim reports has delayed our final report; but the disadvantages of this delay have, we believe, been outweighed by the advantages of having experience as well as theory as the basis for some of our more important recommendations.

CHAPTER II

CLASSIFICATION OF WORKERS AND TRAINING REQUIRED

Types of work involved in achieving radiological health and safety

14. The term "radiological health and safety" covers a wide field, ranging from the fundamental sciences to the preparation of manuals, codes and statutory regulations, and the technical work necessary for their enforcement. The scientific and technical work falls into two main divisions: safeguards, and radiological protection.

Safeguards

15. Safety is an important feature of the design, construction, inspection and operation of nuclear installations. These include nuclear reactors; plants for fuel element fabrication, chemical separation of fission products from irradiated nuclear fuel, or separation of uranium isotopes; and other installations producing radiations (e.g. x-ray machines and high energy particle accelerators). Safeguards work therefore involves the accurate assessment of the safety of particular reactors and plants (including laboratories), the preparation of safety manuals, and related theoretical and experimental studies.

16. The critical scrutiny of a large and complex installation requires specialists in mathematics and many of the applied sciences (heavy civil and mechanical engineering; light engineering applied to control machinery; electrical and electronic engineering; reactor and applied physics, particularly hydrodynamics; and chemistry and metallurgy of irradiated materials).

Radiological protection

17. Radiological protection work is concerned with radiological physics ("health physics") and medical and radiobiological problems in the protection of persons exposed to ionising radiations in the course of their work, as well as the general public. It ranges from fundamental studies involved in the derivation of acceptable standards for human exposure to radiation, to the operational procedures for measuring radiation levels, and the radiation doses received by workers. The work may be sub-divided as follows:—

(a) specification of maximum permissible levels of radiation and radioactive contamination. These levels are based on the advice of the Medical Research Council and of international bodies such as the International Commission on Radiological Protection;

(b) monitoring of working areas to see if safety standards are complied with; and of persons to ascertain the doses of radiation actually

received. The latter includes radiochemical determinations of radioactivity in the human body and in excreta as well as measurement of the dose from external radiation;

(c) medical examination of all workers to ensure a satisfactory initial and continuing standard of health and well-being, and medical supervision of all cases in which excessive exposure to radiation or radioactive contamination may have occurred accidentally;

(d) monitoring of the environment to ensure that the radiation exposure of persons in the vicinity of plants is properly controlled; and

(e) maintenance of suitable facilities to deal with accidents involving exposure to radiation.

Training

18. We envisaged that training in health and safety would be required for two main classes—those who would be fully (or mainly) employed in health and safety duties; and those needing some background training in radiological health and safety work but for whom this aspect would be only one of many responsibilities. The first class would be found mainly (though not exclusively) in the Atomic Energy Authority, the electricity generating boards, the consortia concerned with the construction of nuclear power stations, the hospital services, the Ministry of Power, the Ministry of Housing and Local Government and the Ministry of Agriculture, Fisheries and Food. The second—a more numerous and heterogenous class—would include reactor designers and operators, users of radioisotopes and x-ray machines, managers in industry, and the staffs of government departments and local and public authorities.

Classification of full-time health and safety staff

19. We consider that these can be sub-divided as follows:

Category A: graduates with good honours degrees in science, medicine or engineering. They would be expected to have the capacity ultimately to assume higher managerial responsibilities in the field of health and safety or to play a leading part in the scientific development of the subject;

Category B staff (including a high proportion of graduates) who would have managerial responsibilities for day to day operations or be engaged in research, particularly on the operational aspects. They would supervise the day to day operations of category C;

Category C: supporting staff (without professional qualifications).

Others requiring training

20. The second class of workers referred to in paragraph 18 is very heterogeneous and united only in the need for background training, which may vary from the provision of a booklet or a single lecture, to a residential course lasting two weeks. Alternatively, for example for reactor engineers, it may form part of a much broader training scheme.

CHAPTER III

ESTIMATING THE DEMAND

21. Part of our task has been, as explained in Chapter I, to ascertain the size of the demand for training at different levels. The evidence had to be drawn from many sources; and because the use of nuclear energy for peaceful purposes and of radioisotopes is still in its early stages much of this evidence has inevitably been of a tentative nature. In the following sections we present the estimates of demand given to us by government departments, and by the producers and users of nuclear energy, and information as to needs of industry at large. We then make an estimate of the total number of recruits needed over the next ten years, classified at levels corresponding to the three levels of formal training which are described in Chapter II. The courses of training proposed to meet these needs could readily be adjusted to the demand.

Government departments (civil)

22. The responsibilities of government departments in the field of radiological health and safety stem partly from specific atomic energy legislation and partly from the extension of long-standing departmental functions to cover new aspects revealed by the introduction of atomic energy into our national life. Examples of both bases of responsibility will be given in the discussion which follows of the training demands of the various departments. We consider first the departments with regulatory responsibilities (paragraphs 24 to 43 below).

23. These four departments all need inspectors to deal with various aspects of radiological health and safety, so that they may fulfil their statutory duties of ensuring that food, water supplies and air are kept free from radioactive contamination; of safeguarding the health of workers in occupations involving the production or use of ionising radiations; and of controlling the siting, design and operation of nuclear installations. It might at first sight appear that to have four separate inspectorates is wasteful of skilled personnel, and that a common radiological inspectorate would be an economy. We examined this idea, but came to the conclusion that it was impracticable. The dispersion of control of radiological health and safety among a number of Ministers follows inevitably from the fact that it must be dealt with as part of the separate functional responsibilities of those Ministers (e.g. the Minister of Labour's responsibility for safeguarding workers against hazards cannot stop short when radiation hazards are involved), and control—and the necessary staff to exercise it—cannot be divorced from statutory responsibility. This is the overriding consideration, but in our opinion a common inspectorate, even if practicable, might not effect significant economies in specialist staff. Assessing the safety design of a reactor, for example, calls for a different kind of skill and training from that involved in monitoring gaseous effluent or sampling seaweed; probably as many different specialists would be required to carry out the various functions whether they were dispersed in various departments or grouped together in one inspectorate.

Departments with specific regulatory functions

Disposal of radioactive waste

24. Section 5 (4) of the Atomic Energy Authority Act, 1954, provides that no radioactive waste—solid, liquid or gaseous—shall be discharged from the Authority's premises otherwise than in accordance with authorisations to be given by the Minister of Housing and Local Government and the Minister of Agriculture, Fisheries and Food (in Scotland the Secretary of State). Similar provision was made in the Nuclear Installations (Licensing and Insurance) Act, 1959, in relation to all licensed nuclear installations; but in both Acts the provision is temporary. Further legislation is at present before Parliament (the Radioactive Substances Bill[1]) which will make permanent provision for these controls.

25. The authorisations granted under these powers state in detail the conditions under which discharge is permitted, specifying such requirements as the maximum amount, type, activity, rate, and period of discharge. These authorisations are, in all cases, framed having regard to the permissible radiation dosage to the population likely to be involved. The fact that separate authorisations are required from two departments is due to their differing interests in the matter of possible radioactive contamination. They work in consultation, but they use different criteria and separate studies are necessary. The Ministry of Housing and Local Government may have the major interest in some cases—if, for instance, the main question is the purity of drinking water supplies. The major interest will lie with the Ministry of Agriculture, Fisheries and Food, however, if it is a question of possible contamination of crops, herbage, livestock or fish. Usually both departments have some interest and authorisations are always required from both. The authorisations are given after consultation with such public or local authorities as the departments consider appropriate. Besides issuing authorisations, the two departments (and, in Scotland, the Secretary of State's Department) have the right of entry and inspection and may take samples to satisfy themselves that the conditions of the authorisations are being observed.

Ministry of Agriculture, Fisheries and Food

26. To carry out these duties the Ministry of Agriculture, Fisheries and Food maintain a small staff of inspectors, and laboratories at Lowestoft and Weybridge in which associated testing and research work is carried out. The Ministry state that this work is being expanded and will expand further as nuclear installations become more numerous.

27. A further task of the department is to provide training, against the possibility of a nuclear war, for volunteer agricultural reconnaissance officers and veterinary officers, and to form a food monitoring service by giving short courses of training to civil defence scientific intelligence officers (see paragraph 51 below), public heath inspectors and selected people from the food industry. This training will be carried out by the department's own specialists.

28. In addition the Ministry have to keep abreast of work on the application of ionising radiations to the improvement of agriculture and food production, e.g., the possible use of ionising radiations for the preservation of food and the

[1] See paragraph 79 below.

prevention of deterioration by sprouting or by infestation. The Ministry are also under an obligation to advise the Service departments on the possible application of these techniques.

29. To carry out these duties the department estimate that they will require some thirty-five specialists at all levels during the next ten years. Of these only a few—perhaps three—would be category A staff. The department consider that for all these specialists pre-entry training in radiological health and safety would be valuable, so that their internal training after recruitment could be concentrated on animal or crop husbandry, or fisheries.

Ministry of Housing and Local Government

30. We have already outlined the responsibility of the Ministry of Housing and Local Government under the Atomic Energy Authority Act, 1954, and the Nuclear Installations (Licensing and Insurance) Act, 1959, in paragraphs 24 and 25 above. The Ministry will, however, have additional responsibilities under legislation now pending,[1] which is intended to provide for the registration of all users of radioactive substances (except for certain Crown premises and the users at present covered by the two Acts referred to above); for the control of the discharge of radioactive waste from any premises where radioactive materials are used; and for the establishment of a national waste disposal service.

31. Arising from these responsibilities, there is a need for laboratory facilities for the radiochemical assay of samples of waste. The department suggest that a suitable organisation such as the Government Chemist's Department should establish a radiochemical laboratory, to provide a common service for all departments. We support the idea of a common laboratory service for this purpose.

32. For these duties the department estimate that they may require some six to eight radiochemical inspectors in the next few years. Further augmentation of staff in the latter part of the decade will depend on the rate of increase in the use of radioactive substances. The primary need will be for chemists with some knowledge of radiochemistry. The department do not think that any formal training arrangements are necessary, as the numbers involved are so small that they will be able to make their own ad hoc arrangements for training.

33. The responsibilities of public and local authorities are considered in paragraphs 78 to 84 below.

Ministry of Labour

34. The introduction into factories of new processes using radioactive substances, or machines producing ionising radiations, has necessitated an extension of the duties of the Factory Inspectorate. Draft Regulations[2] have been published containing provisions for the protection of persons employed in factories and other places subject to the Factories Acts. These Regulations deal with the protection of persons liable to be exposed to ionising radiations arising from sealed radioactive sources or from machines producing ionising radiations. Luminising work is already covered by the Factories (Luminising) Special Regulations, 1947, and work is proceeding on a

[1] Radioactive Substances Bill.
[2] Factories (Ionising Radiations) Special Regulations—second preliminary draft 1960.

draft of regulations dealing generally with "open sources". It is therefore necessary for the Ministry to have a small number of highly trained specialist inspectors, and for all members of the general factory inspectorate to have some knowledge of radiological hazards.

35. The responsibilities of the inspectorate include:

(a) routine inspection of factories in which ionising radiations are produced or used;

(b) investigation of special problems arising out of such production or use.

36. The Ministry of Labour consider that it is not necessary to have training facilities specially set up for inspectors, since their needs are being met by participation in existing training courses at various levels, according to the differing requirements of the specialist and general inspectorate.[1] As new courses become available, consideration will be given to their content in relation to the needs of the inspectorate, and when they are suitable inspectors will be sent to them.

Ministry of Power

37. The Minister is empowered, under the Nuclear Installations (Licensing and Insurance) Act, 1959, to set up a system of licensing of sites, under which he will impose safety controls on the design, construction and operation of nuclear installations: he will also be responsible for inspection during construction, commissioning and operation; and for the investigation of any dangerous occurrences. The volume of work in prospect can be judged to some extent by the proposed commissioning dates of the electricity boards' nuclear power stations now under construction, viz:

Berkeley	December	1960
Bradwell	December	1960
Hunterston	August	1961
Hinkley Point	March	1962
Trawsfynydd		1964

38. Four or five other nuclear power station sites have either been approved or are under consideration. In addition to these there are already two low power reactors in private industry, and a few universities are installing, or considering the possibility of installing, reactors for research; but the number of private reactors will probably grow only slowly. Other private industrial installations, however, such as plants for the manufacture of nuclear fuel elements, are likely ultimately to come within the scope of the Act.

[1] *Note.* In the absence of specially designed courses, over fifty specialist and general inspectors have been to the five-day radiological protection course at the Harwell Isotope School; nineteen have been to the course on radiation safety and health physics at the College of Technology, Liverpool. Thirteen medical inspectors have attended the five-day courses at either Harwell or the R.N. Medical School, Alverstoke.

In the more specialised fields, two chemical and two engineering inspectors attended reactor courses (fourteen weeks or six weeks) at Harwell, one chemical inspector a reactor instrumentation course, and one chemical inspector the four-week general course at the Isotope School; each of these courses contained a small element of health physics instruction.

The Chief Inspector of Factories attended the course for directors and senior executives at the Isotope School. A Deputy Chief Inspector attended the 1959 Oxford Summer Conference. Four inspectors attended the International Labour Organisation course held in this country in 1958.

39. Staff required by the Ministry of Power for these duties will mostly be safeguards staff, with basic qualifications in engineering, or in physics, chemistry, or metallurgy. These will all require some knowledge of the principles of radiological protection, but will not need an extensive health physics training. A few health physicists will however be needed as well. The staff will need to be highly qualified, and it is desirable, the department consider, that some should be of M.Sc. or Ph.D. standard; others might be less highly qualified graduates with suitable postgraduate training and experience. The calibre of the more senior staff must be such as to command the respect of senior officers of the electricity boards and the consortia.

40. Authority installations are not required to be licensed under the Nuclear Installations (Licensing and Insurance) Act, but the Authority will (by a Direction under section 3 (2) of the Atomic Energy Authority Act, 1954) be under an obligation to observe the general conditions applying to licensees, and to keep the Ministry of Power's inspectorate informed of their activities in the safety field. Since the Authority are concerned with the development of new types of reactor and new techniques, their knowledge and experience will be of great value to the Ministry of Power inspectorate. For this reason, the Authority have agreed to exchange staff with the Ministry.

41. In addition to the technical licensing staff, the Ministry will have staff responsible for administering the Nuclear Installations (Licensing and Insurance) Act. These will require background training, at the rate of not more than one or two a year.

42. The numbers of scientific and technical staff required over the next ten years can only be very tentatively assessed at this stage. The total number required has been estimated at forty to fifty in the next few years, increasing perhaps to 100-150 by 1970. These numbers would cover the requirements of Scotland and Northern Ireland as well as of England and Wales. The Ministry are now trying to recruit an initial complement of thirty-three. The Authority have undertaken to provide training facilities for recruits during the early stages, and the Ministry do not envisage having any internal training schemes in addition. The initial appointments will have to be filled by experienced people. The training of ten to fifteen graduates a year (perhaps at a higher rate initially) should be sufficient for the build-up and to replace wastage.

43. The needs of the Central Electricity Generating Board and the South of Scotland Electricity Board are discussed separately (see paragraphs 103 to 106 and 117 below).

Other civil departments

Ministry of Aviation[1]

44. The Ministry of Aviation are concerned with radiation hazards in so far as they may arise from the carriage of radioactive substances. There is a

[1]*Note.* The following additional information has been received since the report was submitted:—

The Ministry of Aviation now includes a portion of the former Ministry of Supply, with considerable interests in the use, control and disposal of radioactive matter, arising from the processes of development, manufacture and inspection of war heads for atomic weapons. It also uses x-ray equipment, isotopes and so on. There are local officers to advise heads of establishments on radiological protection and there are co-ordinating officers at headquarters. Recruitment of staff is proceeding but little demand will be made on external training facilities.

considerable traffic by air of radioisotopes, and in 1958, for example, abo 14,000 packages of radioactive materials were carried by air from this country. Operators require to have written permission from the Ministry to do so, which is granted on condition that they observe the International Air Transport Association Regulations relating to the Carriage of Restricted Articles. These regulations prescribe limits to the radioactive content and to the radiation at the surface of packages. They also specify the method of packing.

45. Incidents involving radioactivity risks should occur very rarely, and should be of a minor character only, However, if there should be a breakage or spill at an airport, it would be important for someone immediately at hand to be competent to assess the seriousness of the incident, take the immediate steps necessary to deal with it, and decide whether specialist help was required. Unless someone on the spot did this, any suspected incident would always necessitate calling on expert help (perhaps from some distance) with resulting delays and disruption of the airport's activities. The Ministry have decided therefore that a few employees in their own fire service at London Airport should have sufficient instruction in monitoring to enable them to determine whether specialist help need be called in. The numbers involved will be small, and the instruction required will be background training of a practical nature. Whether the traffic in radioactive materials at other airports is sufficient to justify taking similar action is doubtful, but the Ministry are considering the matter. The Ministry have arranged that fire service staff should take preliminary action to safeguard persons in the vicinity of an incident by keeping them at an appropriate distance.

Ministry of Education

46. The needs of colleges of advanced technology and technical colleges are dealt with in paragraphs 75 to 77 below.

Post Office

47. The Post Office have no demand for training in radiological health and safety. They work in close co-operation with the Radiological Protection Service, on which they would expect to call for specialist help if needed.

Ministry of Health

48. The Ministry of Health state that they have no training requirements. The evidence we received from the Ministry related therefore to the needs of the hospital service and of the medical profession generally (see paragraphs 81, 82 and 85 to 93 below).

Home Office

49. The Home Office have no specific responsibility for radiological health and safety in peace-time. They have, however, an interest arising from their long-standing departmental responsibility for maintaining public safety. An emergency involving radioactivity hazards might involve the police and perhaps the fire service, who will require at least some degree of training. These questions are at present under examination by the Central Fire Brigades Advisory Council. It may be necessary to find lecturers to deal with the instruction of the higher ranks at residential centres such as the Fire Service College.

50. Police functions in emergencies involving radiation would merely be an extension of their normal duties and they would look to another service to undertake the technical responsibility of monitoring. The Home Office, therefore, take the view that only a limited amount of training is likely to be required for police.

51. Though a large number of people have gained from their civil defence training some knowledge of radiation hazards in nuclear warfare, the Home Office do not consider that civil defence courses can be regarded as directly applicable to peace-time hazards. However the volunteer scientific intelligence officers in the civil defence organisation (numbering some 1500) are qualified scientists. We consider, therefore, that if they were given some appropriate instruction additional to their civil defence training, to enable them to assess the significance of peace-time incidents, they could play a useful part—especially as they are widely distributed over the country—in giving "first aid" advice in case of alarms or accidents. To enable them to do this, they would have to have some recognised position and fit into some organisation; they might, for instance, be registered as local auxiliaries in a national network of emergency services managed by the advisory service proposed in Chapter IV. The Home Office suggest that consideration should also be given to the extent to which the Royal Observer Corps could be of assistance.

52. The Home Office expect to make very little call on external training facilities (except perhaps for some training for a few lecturers) but would expect to be able to call on specialist help in case of need.

Ministry of Transport

(i) Ports and shipping

53. There are four aspects of the problem of trained staff for radiological health and safety in connection with ports and shipping:—

(a) the transit of radioactive substances through U.K. ports;

(b) the licensing of nuclear-powered ships constructed or repaired in U.K. yards;

(c) the presence of nuclear-powered ships (U.K. or foreign-registered) in U.K. ports;

(d) the safety of seagoing personnel in nuclear-powered ships.

54. *Transit of radioactive substances through U.K. ports.* An increasing volume and variety of radioactive substances are now being handled in our ports. Some twelve major ports will require staff (say, one or two at each) trained to deal with health and safety problems; some will need training to category C level, and a few to a higher level. Some ports might be able to rely on specialist help from outside, when needed, if such help could be made available. The department think they might require the training of about twenty health and safety staff in ports, who will mostly be required in the earlier years of the decade; about four of them would be graduates and the rest technicians. Some economy may be achieved by co-operation with the Ministry of Health's Port Health Division.

55. *Licensing of nuclear-powered ships.* As in the case of land-based reactors which will be licensed by the Ministry of Power (see paragraph 37 above),

machinery will be necessary for licensing nuclear-powered merchant vessels—for all stages, from design to operation. The Ministry of Transport do not contemplate building up their own staff of specialists for the licensing of nuclear-powered ships, but will use the services of the Ministry of Power inspectorate, and meanwhile of the Authority, to supplement the marine survey service.

56. *Nuclear-powered ships in U.K. ports.* It is not at present expected that there will be more than a few nuclear-powered ships on the U.K. register before 1970, but the presence of nuclear-powered ships in U.K. ports is a more immediate problem. The amount of nuclear shipping in U.K. ports, however, and the number of ports involved at any one time, are not likely in the near future to call for any considerable staff in the individual ports. Perhaps ten may be needed by the port authorities. Ministry staff who will be concerned are marine surveyors, who will be responsible for:

(a) ensuring that U.K. registered nuclear ships operate within the terms of their licences, and that the requirements of the ship's operating manual are complied with;

(b) ensuring that the necessary standards of safety have been applied in the design, construction and operation of foreign-registered nuclear ships, before admitting them to a U.K. port;

(c) inspecting nuclear-powered ships (U.K. and foreign-registered) proceeding to U.K. ports, and issuing certificates of entry;

(d) together with port and other local authority staff (and initially with members of the Authority's staff), applying safety measures after any accident involving a nuclear-powered merchant ship.

Some Ministry surveyors need training now, and possibly ten by the end of the decade; we consider that the most appropriate training would be that given to "safeguards" staff (see Chapter VI). A number of senior marine surveyors have already attended courses at Harwell—either the standard sixteen-week reactor course or the senior technical executives' course. A senior engineer and ship surveyor is at present attached to the Authority.

57. *Safety of seagoing personnel.* The Ministry estimate that each nuclear-powered merchant ship will need at least four engineer officers who have been given a course of instruction in radiological health and safety as part of their operational training, as well as three deck officers and three junior engineers whose training in the subject need not be so extensive. These officers will be operational staff, not in any sense health and safety specialists. Allowing for replacements, the number concerned might be 60-75 by 1970. They will in fact receive detailed training during the construction of the vessels; operational courses lasting fifteen months for the senior engineering staff, and a shorter period for masters, deck officers and junior engineering staff, will be provided. An element of health and safety training will have to be included in the courses. How the courses will be provided is not at present determined but we are informed that they will probably be arranged by the Admiralty, Ministry of Transport and the shipbuilders in collaboration. Any foreign going vessel (whether conventional or nuclear-powered) having 100 persons or more on board, is obliged to carry a qualified medical practitioner; any ship's doctor

on a nuclear-powered ship will also be required to be qualified to assess and advise on effects of radiation. The numbers involved will not be such as to present a training problem.

58. To sum up, the need for special training in respect of ports and shipping[1] is not large: for dealing with radioactive freight, say twenty, spread over the decade, of whom three or four might be graduates and the rest technicians; for nuclear-powered shipping, about ten Ministry surveyors and ten port authority staff, and a small number of ship's doctors.

59. *Marine classification societies.* The marine classification societies (e.g. Lloyd's Register of Shipping and the British Committee of Bureau Veritas) will, in the Ministry's view, need to have a small number of marine engineer and ship (naval architect) surveyors trained in safeguards work, and one or two have already been sent to the U.S.A. for courses.

(ii) Inland transport

60. For road transport, the Ministry do not require any specialist staff for drafting or revising regulations on the carriage of radioactive goods, though they need to have specialist advice. Where highly radioactive loads are concerned (e.g. irradiated fuel elements) the Ministry propose that hauliers should apply to the Ministry for an authorisation in respect of each class of operation; the conditions of carriage will be so stringent that the number of operators is likely to be very small, and any necessary inspection could probably be carried out by the Ministry of Power's reactor licensing inspectorate without any additional staff. Eventually it may be necessary for British Road Services to have one or two men trained to category B level, and about forty men (one in each region) with category C health and safety training.

61. The British Transport Commission do not expect to have more than about a dozen of their railway staff trained at first. These will be mainly scientists from their research staff, with perhaps some members of the traffic department. It would probably be appropriate for the scientists to receive category B training, and the Commission would look to them for advice on their own internal programme, including the training of civil defence and fire-protection sections in the regions. Background training would be suitable for administrative staff in the traffic department.

[1]*Note.* Since the report was completed information has been received from the Ministry of Transport, after consultation with the Shipbuilding Employers' Federation, about the possible training needs of the shipbuilding industry.

It is unlikely that the purely structural side of the shipbuilding industry will be called upon to carry out special additional health and safety duties during the construction of nuclear-powered ships, but background knowledge would be required at assistant manager/foreman level. Many shipyards however, and particularly those likely to go in for the construction of nuclear-powered ships, have marine engineering sections and in association with nuclear engineering firms will design, build and install the machinery in nuclear-powered ships. They will have to ensure proper safety precautions during initial fuelling and subsequent repairs and service. The ship-repairing industry is unlikely to be called upon to undertake repairs to nuclear-powered plant: this would probably be done by the original suppliers. It is expected that the trained crew of a nuclear-powered ship would provide the staff for safety duties while any other repairs were being carried out.

Some six shipbuilding yards might be interested, and over the decade training might be required for about twelve category A staff, forty category B, and ninety category C (as well as background training). The firms would probably set up their own arrangements for category C and background training.

62. We note that the Ministry intend to avoid setting up a staff of specialists of their own and expect to work in close conjunction with the Ministry of Power and the Authority, and to call on specialist help if required. This implies that staff of other departments or organisations must be available to deal with their problems when they arise.

Ministry of Works

63. The Ministry of Works would wish to have short courses available for a small number of their professional staff, as it is increasingly important for public health engineers to be familiar with the impact of radioactive materials on services such as drainage and water supply.

Other Government Departments and Agencies

64. We are informed that the Medical Research Council and the Agricultural Research Council have no need for training facilities, as they train their own recruits.

The Service departments and the armed forces

65. We have asked the Service departments about their probable requirements and those of the three Services, for training in radiological health and safety over the next ten years. In making these enquiries we assumed (although there was no specific limitation in our terms of reference) that the training of Service personnel was not a matter for us, unless Service departments themselves might wish to put forward any such requirements for our consideration. We thought, however, that the need for trained civilian personnel should be considered.

66. Our information is by no means detailed, but the numbers involved are not great, and we hope that some of the courses which we recommend will be useful to the Services insofar as they have a need for external training.

Admiralty

67. The Admiralty state that health and safety duties will arise in connection with:

(a) decontamination after, or during refit or survey of, nuclear propulsion plants;

(b) handling of radioactive stores, including nuclear weapons;

(c) operating, maintaining or repairing nuclear reactors;

(d) using radiological equipment and radioisotopes; and

(e) manning of nuclear-powered ships.

Most of these duties will be carried out by uniformed personnel, but a few trained civilians will probably be needed also.

68. The Admiralty cannot as yet estimate the numbers with any accuracy, but they think the numbers requiring training during the decade will be of the following order:

professional staff (including medical officers)	15
non-industrial technical staff	35
industrial staff	50

For the most part the Admiralty expect that naval and civil personnel (including those needing background training) can be trained within the Service. They would like to be able to nominate up to three persons a year for a course if available.

War Office

69. In the Army, health and safety duties arise in connection with:

(a) the handling of nuclear weapons;
(b) radiological defence (including safety aspects of any accidents involving nuclear material);
(c) use of radioactive sources for calibration and testing of radiac instruments, and for industrial radiography;
(d) disposal of radioactive waste;
(e) luminising;
(f) testing and repair of x-ray and other equipment.

Most of the duties would be carried out by uniformed personnel, but civilians might have health aud safety duties, especially in the Works Organisation and the Army Medical Services.

70. Present Army training courses do not deal specifically with peace-time radiological hazards and facilities are lacking for training personnel of the Army Health Organisation and Works Organisation, and also those in employment of an industrial nature who require some knowledge of radiological health and safety. The Army therefore make use, for the medical services, of the five-day courses in radiological protection at Harwell.

71. The War Office would welcome additional training facilities, and they also feel the need for some specialist organisation on a regional basis which the Army authorities could consult locally, in addition to the present arrangements for obtaining consultant opinion at a high level.

72. The numbers which the War Office envisage as needing training during the next ten years are:

Civilian personnel

Professional staff, Works Organisation	8
Technical officers, Works Organisation	5

(Electrical and Mechanical Engineers—perhaps a few also)

Service personnel

Army Medical Services	100 medical officers and 20 other ranks
Royal Artillery	30 officers and non-commissioned officers
Other arms	about 20 officers and non-commissioned officers

Of these the War Office consider that only the specialists in Army Health need a considerable degree of training. Short courses would be adequate for the rest.[1]

Air Ministry

73. In the Royal Air Force, radiological health and safety duties arise in connection with:

(a) the handling, storage, transport and testing of nuclear weapons;
(b) the provision of teams for monitoring, decontamination, etc., to deal with any peace-time accidents involving radioactive materials;
(c) radiological defence;
(d) industrial and medical uses of radioactive materials.

These duties would be mostly carried out by uniformed personnel. Broadly speaking, the Royal Air Force at present meet their own training requirements with the assistance of the Authority, the War Office research establishments and the Joint School of Nuclear Defence. The Air Ministry think it would be valuable if selected R.A.F. personnel—about fifteen a year, possibly increasing in a few years' time—could attend background courses.

74. The Royal Air Force expect to be able to process their own film badges, but they use the services of the Radiological Protection Service, and would wish to continue to rely on such help.

Universities, colleges of advanced technology, and technical colleges

75. One demand which we did not try to estimate is that for the training of teaching staff at universities and technical colleges, for two reasons: first, until it became clear what kinds of courses we should recommend, in what kinds of institutions or by what means we thought they should be provided, and what the size of the demand was likely to be, we could not assess what load would fall on the various educational institutions or the staff necessary to carry it. In the second place, it would not be particularly helpful for us to make any estimate of the teaching staff who would require training, since the institutions would be far better able to do this themselves if they knew the general requirements they were being asked to meet. Clearly, too, if courses are given in universities or at colleges of advanced technology, the university or college will try to retain such of its own students as it needs for teaching purposes.

76. In addition to their teaching commitments, the increasing use of radioactive substances and ionising radiations in universities and colleges makes it necessary for them to consider the resulting problems of radiological health and safety. An inter-university committee is working on a code of practice for use in university laboratories, and a panel of the Radioactive Substances Advisory Committee is working on the arrangements required by research laboratories, including those in universities. The whole trend of discussions

[1] *Note.* The following additional information has been received since the report was submitted:—
The War Office now includes a portion of the former Ministry of Supply with considerable interests in the field of ionising radiations, especially as they find application in research and development establishments and in routine processes of inspection of items manufactured in Royal Ordnance Factories.
There are local officers to advise heads of establishments on radiological protection and there are co-ordinating officers at headquarters. Recruitment of staff is proceeding but little demand will be made on external training facilities.

in the universities in relation to this code of practice has been towards the part-time use of graduate staff as radiological safety officers; technical assistants in the laboratories (with perhaps some extra ad hoc training) will probably be employed part-time to assist them. It seems unlikely therefore that any staff will be required other than those engaged in research or teaching. The number concerned would be about thirty in all.

77. Technical colleges have received advice on this subject from the Ministry of Education and "Notes for Guidance" prepared by the Educational Panel of the General Purposes Committee of the Radioactive Substances Advisory Committee. Safety officers have been appointed in some forty colleges, and laboratory personnel have been given individual training in safety matters.

Local and public authorities

78. The chief interest of local and public authorities arises from the disposal of radioactive wastes. As the law now stands, the temporary provisions in the Atomic Energy Authority Act, 1954, and the Nuclear Installations (Licensing and Insurance) Act, 1959, constitute the only controls which expressly apply to the radioactive content of wastes (see Appendix B). The only other statutory controls are those provided in the general body of legislation relating to public health, the purity of rivers, and the protection of fisheries.[1]

79. The Radioactive Substances Bill now before Parliament is designed to remedy this situation as well as to make permanent the provisions of the Atomic Energy Authority Act, 1954, and the Nuclear Installations (Licensing and Insurance) Act, 1959, referred to above. Under this Bill, local and public authorities would have no direct responsibilities in regard to radiation hazards from radioactive wastes. However,

(a) such local authorities, river boards, local fisheries committees' statutory water undertakers, and other local or public authorities as appear appropriate would be consulted by the Minister of Housing and Local Government or the Minister of Agriculture, Fisheries and Food before any authorisations were given for the discharge of radioactive wastes from Authority sites or from sites licensed under the Nuclear Installations (Licensing and Insurance) Act, 1959;

(b) the above authorities might be called into consultation, where appropriate, by the Minister of Housing and Local Government in the case of authorisations to all other users, and would have to be so consulted if an authorisation entailed special precautions on the part of an authority;

(c) in all cases, whether or not consultation had previously taken place, copies of all authorisations would be sent to the county borough or county district council for the area;

[1] The Rivers Pollution Prevention (Scotland) Act, 1876
The Public Health (Scotland) Act, 1897
The Salmon and Freshwater Fisheries Act, 1923
The Public Health Act, 1936
The Public Health (Drainage of Trade Premises) Act, 1937
The Water Act, 1945
The Water (Scotland) Act, 1946
The Rivers (Prevention of Pollution) Act, 1951
The Rivers (Prevention of Pollution) (Scotland) Act, 1951

(d) the Bill also provides for the registration of all users of radioactive substances with the Minister of Housing and Local Government; the Minister will (subject to considerations of national security) send copies of all registrations to the county borough or county district council for the area, the intention being that comprehensive local records should be kept by them for their own use and for the benefit of other local or public authorities (e.g. fire authorities, river boards, sea fisheries committees, and statutory water undertakers) with a bona fide interest in the use or discharge of radioactive substances in the area.

80. Local authorities have however a number of statutory responsibilities in regard to the protection of the health of the public. As one example, their functions under the Food and Drugs Act, 1955, give them an interest in any possible contamination of the environment. We feel that the extent of this interest is not sufficient to warrant the employment by local authorities of full-time radiological health and safety specialists; we believe that—particularly if specialist advice is available if required—the needs of local authorities will be met suitably by background training for selected members of their staffs.

Medical officers of health

81. The local authorities will look in the first instance to their medical officers of health for advice on radioactive waste and on radiation hazards generally. It is therefore in our view essential that medical officers of health and many of their staff should have a good background knowledge of radiological health and safety, especially in areas where special hazards might arise. Medical officers of health have wide obligations to inform themselves "as far as practicable respecting all matters affecting or likely to affect the public health" in their areas, and to "be prepared to advise"[1] their local authorities on any such matter.

82. So far the training of medical officers of health has generally taken the form of short courses run by the World Health Organisation (three weeks), the Society of Medical Officers of Health (three days and one week) and the Western Regional Hospital Board, Scotland (three days), but other general courses exist (e.g. the five-day course in radiological protection at Harwell) which interested medical officers of health have been able to attend.

Other local and public authority officers

83. Statutory water undertakers (which may be companies, local authorities or joint boards) have a particular interest in the possible radioactive contamination of water, since they are under a statutory obligation to supply only wholesome water. They will therefore wish to be able to satisfy themselves that that water they distribute is free from excessive radioactivity as well as other contamination, and water chemists—of whom there are under 100—need specialised training. Residential two-week courses for water chemists have been arranged by the Harwell Isotope School, and the Ministry of Housing and Local Government hope that these will continue.

[1] Memorandum on the duties of medical officers of health (Ministry of Health, 1925).

84. Municipal engineers, water engineers, river board officers, and perhaps also public analysts, like medical officers of health, require a good background knowledge of radiological health and safety.

Hospitals and the medical profession

Hospital physicists

85. Much of the radiological protection in hospitals[1] is carried out by, or under the supervision of, the hospital physicists. These duties include personnel monitoring; radiological surveys of departments; advice on the layout and construction of radiological departments[2]; and advice and help if any accidents occur. In some areas these services have been developed on a regional basis, and it is the Ministry's aim that this development should continue. The duties of a hospital physicist are not however by any means restricted to radiation physics.

86. The total number of physicists in the hospital service, the Radiological Protection Service, and research laboratories such as the Medical Research Council units, is about 150; the number of technicians is about the same. The hospitals' need for physicists will increase, and the wastage may be considerable, as physicists in the hospital service are at present being lost to other occupations, but it seems that an intake of twenty to thirty new physicists a year, and a similar number of technicians, should be sufficient, unless additional and unforseen responsibilities are laid upon them. The basic qualification of the hospital physicist is an honours degree in physics, and he receives his professional training on the job. A new recruit normally goes to a large hospital where there are good opportunities of gaining wide experience, and training on the clinical aspects of the work can only be given in this way. In the opinion of the Hospital Physicists' Association, courses in radiological health and safety would not be appropriate as the sole professional training for hospital physicists, but short courses of an advanced kind for hospital physicists in post would be advantageous.

87. We welcome the formation of regional physics services (paragraph 85 above) as a step likely to improve health and safety measures in hospitals while economising in specialist personnel. We emphasise the importance of having an adequate supply of well-trained physicists—some trained to the highest level—for the hospital service. This is essential, not only to ensure a more adequate control of health and safety measures in hospitals, but also to enable the hospital physicists to carry out their primary hospital duties and to play their part in the internal training referred to in paragraphs 89 and 90.

Other hospital staff

88. Other hospital staff with a high degree of responsibility for health and safety are radiologists, both diagnostic and therapeutic. They receive extensive instruction in this subject during their specialist training and are generally in charge of radiological protection in hospitals. Radiographers, both diagnostic

[1] Guidance for the staff concerned is embodied in the "Code of Practice for the Protection of Persons exposed to Ionising Radiations", prepared by the Radioactive Substances Advisory Committee (H.M.S.O. 1957). (This is in course of revision to include more recent findings and recommendations).

[2] These are subject to Ministry of Health approval, which is only given after clearance by the Radiological Protection Service.

and therapeutic, require adequate training in radiological health and safety in the two-year syllabus for membership of the Society of Radiographers. In many instances they have important duties in radiological protection under the direction of radiologists and physicists.

89. There are many other users of ionising radiations in hospitals. They range from the senior physicians, surgeons, gynaecologists and dermatologists (who may be using, e.g., radium, radioactive isotopes and x-ray apparatus for a wide variety of therapeutic, diagnostic and research procedures) to junior medical and nursing staff who are concerned with patients undergoing radiological treatment or investigation. Routine training for such staff has not so far been available and we consider it important that some provision should be made. There will therefore be a considerable number of medical, nursing and other hospital staff who will need appropriate health and safety training.

90. The Ministry of Health consider that the hospital service will be able to do all its own training internally.

Doctors in industry

91. Firms using or producing ionising radiations on a large scale will need a works medical officer with considerable knowledge of health and safety, but the number of such firms will not be large. It is likely that most works medical officers will need only background training.

92. Under the draft Factories (Ionising Radiations) Special Regulations, there are requirements regarding the medical supervision of workers; the duties are to be carried out by the "appointed doctor" who may be either a doctor specially appointed by the Chief Inspector of Factories for this purpose or the appointed factory doctor for a district. The draft does not contain requirements for special training of the appointed doctor in radiological health and safety. The medical inspectors of factories will be in close touch with the appointed doctors and the help of all branches of the factory inspectorate will be available to them. The Ministry of Labour also propose to issue to appointed doctors an advisory publication in connection with their duties under the Regulations. We think that many of these will also require background training.

General practitioners in post

93. Some background training will be needed for general practitioners in post, particularly in the neighbourhood of United Kingdom Atomic Energy Authority establishments or nuclear power stations. Indeed the Central Electricity Generating Board propose to make arrangements with local doctors, and if this is done more than background training will be required.

The United Kingdom Atomic Energy Authority

Organisation

94. The Authority have four Groups:

(a) The Research Group, with headquarters at the Atomic Energy Research Establishment, Harwell, carries out fundamental research in the nuclear sciences; basic research and early development on nuclear power generation; and radioisotope production. In addition

it is responsible for research into controlled thermonuclear reactions. Other Research Group establishments handling significant quantities of radioactive materials are the Atomic Energy Establishment, Winfrith (reactor experiments), the Wantage Radiation Laboratory (research into the uses of radioisotopes and their radiations) and the Radiochemical Centre, Amersham (production and marketing of radioisotopes).

(b) The Weapons Group, with headquarters at the Atomic Weapons Research Establishment, Aldermaston, undertakes design and development of atomic weapons. It also undertakes fundamental research, for instance in metallurgy and fuel element design and on controlled thermonuclear reactions.

(c) The Development and Engineering Group, with headquarters at Risley, undertakes the development, design and construction of reactors and associated plant; and engineering consulting work for the nuclear engineering consortia, the electricity generating boards, and oversea organisations. The Group includes the Dounreay Experimental Reactor Establishment and the Culcheth Laboratories together with research and development laboratories associated with the Authority's factories at Springfields, Capenhurst and Windscale.

(d) The Production Group, with headquarters at Risley, operates the Authority factories and carries out research and development in aid of factory processes. The main factories of the Authority are:—Springfields, where uranium metal, oxide and hexafluoride are produced from uranium ores and concentrates; Capenhurst, where there is a gaseous diffusion plant for separating uranium-235; Calder Hall and Chapelcross atomic power stations; and Windscale, where the chemical processing of irradiated fuel elements is carried out.

In addition there is a central Authority Health and Safety Branch to which detailed reference is made below.

95. The Authority have an absolute statutory duty to ensure that their operations do not cause harm either inside or outside their establishments. This duty is a major concern of all Authority staff responsible for operations, large or small. They are responsible to the Authority, through the management chain of command, for the safety of operations under their control.

96. Complementary to the operational staff there are advisory health and safety specialists at each major establishment. They are responsible to the head of the establishment and have the following main functions:—

(a) to advise the head of the establishment on the health and safety aspects of the work of the establishment;

(b) to provide a suitable range of health and safety services for the establishment; and

(c) to carry out investigations and research in the health and safety field.

97. The Authority Health and Safety Branch, which is part of the Authority's headquarters organisation, has the following main functions:

(a) to advise the Authority on the formulation of their health and safety policy and to disseminate this policy for application by heads of groups and establishments;

(b) to apply this policy to the safety evaluation of reactors and plant (including laboratories); and

(c) to conduct the Authority's external relations (both technical and political) in the health and safety field.

The Authority's health and safety staff

98. The duties of medical, scientific and technical staff required for full time health and safety duties in the Authority are outlined in Chapter II under the headings "radiological protection" and "safeguards". The numbers are given below.

Radiological protection

99. The Authority estimate that during the next ten years they will require to recruit a total of about eighty staff in category A, i.e. specialists in radiobiology and radiological physics. Initially about ten will be required each year, but this will level off by the end of the period to about five each year.

100. The Authority also estimate that over the next ten years they will require to recruit about eighty in category B (initially about ten will be required each year levelling off by the end of the period to about five each year), and about 200 in category C (at the rate of about twenty each year).

Safeguards

101. The Authority consider that the present training arrangements for safeguards staff are adequate to meet their foreseeable needs. The reasons are given in Appendix C.

Other staff

102. Apart from the needs for their specialist health and safety staff there is a general and continuing need to cater for the education in safe practices of large numbers of employees of the Authority at all levels and, particularly, those with operational responsibilities. This is discussed in more detail in Chapter VIII (The Role of the U.K.A.E.A.).

The Central Electricity Generating Board

103. In the nuclear power stations of the Central Electricity Generating Board major consideration is given to questions of radiation safety. The task of ensuring radiological safety at the stations is well defined and specialist staff are available who already have long experience of these matters. We do not consider it necessary to describe the duties of health and safety staff at headquarters or stations, since they are closely analogous to those of Authority health and safety staff.

104. The Board estimate that they will require over the next ten years:

	At H.Q.	*At stations*	*Total*
Category A	20	30	50
Category B	15	45	60
Category C	—	250	250

Most of the headquarters staff will be required within a year or two, and the increase in the number of stations will not lead to a proportionate headquarters staff requirement. (The proposed commissioning dates of nuclear power stations now under construction are shown in paragraph 37 above). Partly because a considerable proportion of the senior posts will have to be filled by taking trained staff from elsewhere, before there is any output from courses initiated by this Committee, the Board estimate their demand on external training facilities (taking account of wastage) as follows:

	Average annual requirement
Category A	3
Category B	5
Category C	10

However their recruitment of trained staff in the initial stages (as in the case of the Ministry of Power—paragraph 42 above) will create shortages elsewhere; these will have to be made up and will in fact be reflected in an increased demand from some other source.

105. The number of places required for training of category C employees is estimated at only ten a year, since the majority of employees in this category will be trained internally. The geographical distribution of the technical colleges at which suitable courses are available will in any case strongly affect the extent to which technical college courses (and especially part-time courses) are of value for training Central Electricity Generating Board staff. This is an important factor in the consideration of technical college courses generally, and not only in connection with the Board.

106. Background training in health physics for station staff and some headquarters staff will be provided internally, and training arrangements with the Authority and Whitehaven College of Further Education are expected to continue.

Industry

The consortia

107. The consortia are particularly concerned with the industrial applications of nuclear power and with the building of nuclear power stations both at home and abroad. They will need health and safety staff in order to carry out their responsibilities during the period of design, construction and commissioning. In the U.K., the responsibility for health and safety is laid on the contractors until a power station is commissioned; responsibility then passes to the electricity board concerned. However, in practice, the expert staff of the electricity boards co-operate closely with the consortia at all stages; this is obviously desirable and should obviate wasteful duplication of effort. This fact—and the fact that the consortia, while operating at home, will be working

on a highly developed nuclear programme in a country where knowledge is advanced and specialist help available—will reduce the health and safety requirements of the consortia for their U.K. commitments.

108. As regards export orders for nuclear power stations, it will be essential for the consortia to have well qualified health and safety staff to advise their oversea customers. They would have to be able to take responsibility, in the importing country, both for health and safety on the site and for advising on public health problems; the latter would probably involve discussions with the specialist staff of the appropriate authorities of the country. It seems to us, therefore, that the consortia need health and safety specialists of a high calibre in connection with export orders.

109. The outlook is at present so unclear, however, that it appears impossible to make estimates of the needs of the consortia for trained health and safety staff. We are satisfied that the arrangements we are recommending are sufficiently elastic to adapt themselves accordingly.

Other industry

110. Radioactive substances and ionising radiations are employed by several hundred firms for a variety of purposes, and their use is increasing: for thickness measurements, for elimination of static electricity, for liquid level indication, for surveillance of pipe-lines, for detection of leaks, for radiography of welds and internal mechanisms, as tracers in mixing techniques, etc. When the draft Factories (Ionising Radiations) Special Regulations come into force under the Factories Acts all users of ionising radiations covered by the Acts will be under a statutory obligation to "appoint a competent person to exercise special supervision with regard to the requirements of these Regulations, and to assist by instruction in safe working methods, monitoring and otherwise, in enforcing the observance of them".

111. The knowledge required by the "competent person" will vary according to the nature and extent of the use by the firm of radioactive substances and ionising radiations. His duties under the Regulations may be considerable or they may occupy only a very small part of his time. Some degree of training will be required for a large number of workers in industry, even if only to enable them to carry out routine precautions, to detect trouble promptly if it should arise, and to know where to obtain expert help.

112. We have found it very difficult to estimate the total needs of industry for health and safety training. We have no doubt, however, that there will be a demand for training for "competent persons" when the present draft Regulations come into force; that few firms are likely to need a full-time health and safety officer; and that many firms will need employees with some elementary training who will be occupied for only a small proportion of their time on health and safety duties. Such firms will have to be able to look outside for advice and services (e.g. processing of film badges), as a number already look to the Radiological Protection Service.

Scotland

113. We have considered the separate needs of Scotland for training in radiological health and safety. As explained above the Secretary of State for

Scotland has statutory responsibilities with regard to the licensing of nuclear installations and to authorisations for disposal of radioactive waste (and, under the Radioactive Substances Bill, for the registration of users and premises). There are two major Authority establishments in Scotland, at Chapelcross and Dounreay, and the South of Scotland Electricity Board have a nuclear power station under construction at Hunterston. The needs for various kinds of training in radiological health and safety of, for example, medical officers of health, officials of local and public authorities, hospital staff, the police and fire services, and workers in industry, are similar to those outlined in earlier parts of this chapter, though on a smaller scale. The following estimates have been given to us by the Scottish Office.

114. *Licensing of nuclear installations.* Background training will be necessary for a few staff—say three—who will be concerned in administering the Nuclear Installations (Licensing and Insurance) Act, 1959, in Scotland. The technical work will be undertaken by the Ministry of Power.

115. *Disposal of radioactive waste.* Three or four chemical inspectors will be required, who will be responsible for the disposal of radioactive waste. There is a separate inspectorate in Scotland, which works in close co-operation with the inspectorate of the Ministry of Housing and Local Government.

116. *Local and public authorities.* Background training is needed for medical officers of health (for whom the Western Regional Hospital Board, Scotland, have already provided three-day courses), and for some sixty water engineers and river purification board officers.

117. *The electricity boards.* Staff of the South of Scotland Electricity Board are at present being trained by the Authority, and the Scottish Home Department expect that staff both for this Board and the North of Scotland Hydro-Electric Board will be trained by the Authority and later by the Central Electricity Generating Board.

Northern Ireland

118. We have also considered the separate needs of Northern Ireland and have consulted the Departments of Agriculture, Commerce, Education, Health and Local Government, Home Affairs, and Labour and National Insurance. No nuclear installations exist or are at present planned in Northern Ireland. Radioisotopes are used for agricultural purposes only by the Ministry of Agriculture and Queen's University, Belfast, and the use of isotopes in industry is not yet extensive. The demand for training in radiological health and safety is therefore small. However, under the Radioactive Substances Bill, the Minister of Health and Local Government for Northern Ireland is proposed as the authority to be responsible for registering users of radioactive substances, and for authorising radioactive waste disposal.

119. The main requirements for training at present will, therefore, be:

(a) background training for medical officers of health, water engineers and other public officials (a number of medical officers of health from Northern Ireland have attended the three-day courses, already referred to, run by the Western Regional Hospital Board, Scotland);

(b) training for factory inspectors (two factory inspectors and the medical inspector of factories have attended the five-day course in radiological protection at Harwell—see paragraph 36 above);

(c) training for the police and fire services similar to that indicated in paragraphs 49 and 50 above;

(d) training for workers in industry who may be concerned with the use of radioactive substances or ionising radiations.

120. The Northern Ireland departments work in close contact with the Radioactive Substances Advisory Committee and with departments in Whitehall, and have already made use of training facilities available in Great Britain. They would continue to do so for courses for which the potential demand would not justify the setting up of courses in Northern Ireland.

The Channel Islands and Isle of Man

121. The needs of the Channel Islands and Isle of Man for training in radiological health and safety have not been examined in detail. We have assumed that they will be covered by our estimates and recommendations for the United Kingdom as a whole.

Oversea students

122. We think it would be very unfortunate if those from other countries wishing to be trained in radiological health and safety in the United Kingdom could not be accepted because suitable training facilities were not available. This country has a leading part to play in the development of atomic energy generally, and in the health and safety field in particular. It is natural that Commonwealth countries and Colonial territories should turn to this country for training. Foreign countries may also look to us for any training which cannot be provided nearer home.

123. We collected a great deal of information—necessarily very tentative for the most part—about the possible size of the oversea demand during the next decade. It appears that a small number would be likely to require post-graduate training to M.Sc. or Ph.D. level; for some a course at a college of advanced technology would be appropriate. Others—public health officers and administrators—would need background courses only. We do not think that any attempt need be made to assess the exact numbers, as we consider that the training facilities we are recommending will be able to accommodate oversea students without difficulty.

Conclusion

124. From the above information the best estimate we have been able to make is that the total numbers requiring training over the decade will be approximately—

Category A . .	200
Category B. . .	300
Category C . .	600

(No figures for background training are given—See Chapter VII below).

We think that this estimate of the demand may be taken as a basis for setting up courses in the first instance. If the demand proves larger, there should be no difficulty in expanding the training facilities to meet it.

125. The demand will not be evenly distributed over the years. Some needs (e.g. in connection with nuclear-powered shipping) will not develop until late in the decade, but it seems clear that the major employers will require more people to be trained in the early years, and that the demand will taper off towards 1970. For this reason, and to make good the arrears, the initial courses should be able to accommodate annually rather more than one-tenth of the total number given for the whole period.

CHAPTER IV

PROPOSALS FOR A NATIONAL RADIOLOGICAL ADVISORY SERVICE

126. The rapid and continuing expansion of work involving ionising radiations has been accompanied by a progressive increase in the demand for trained health and safety staff at all levels. The problem is complicated by the fact that work involving ionising radiations varies from the large-scale operations of the Atomic Energy Authority on the one hand, to the incidental use of radioisotopes or x-ray apparatus as "tools" on the other.

127. If all organisations concerned with the use of ionising radiations were to attempt to employ their own full-time specialist health and safety staff, it is obvious that the total demand would be beyond the available resources of the country. The result would be a wasteful deployment of skilled manpower and inadequate supervision of many important activities.

128. The first call on the nation's limited resources of highly trained staff must inevitably be for those organisations whose operations demand that they should themselves employ full-time health and safety specialists. An effective means is required to meet the needs of the large number of smaller organisations, whose aim should be to have staff with sufficient training to deal with day to day problems and to know when and where to seek advice from those with more advanced knowledge.

129. We therefore came to the conclusion that the only way of providing the services of health and safety specialists to those organisations not requiring them full-time would be to establish a national radiological advisory service. We believe that this would make possible both a more rational and efficient deployment of that part of the nation's resources of scientific and technical manpower which can be devoted to radiological health and safety duties, and at the same time an effective national supervision. Such an organisation would not only improve the control but would also inspire greater public confidence that the problems were being tackled in the most efficient possible manner.

130. Our proposal would lead to a reduction in the demands on the Authority. They are at present asked to devote a significant proportion of their strained resources to providing advice and assistance to outside organisations. Hitherto the Authority have recognised their moral obligation to provide this help, but it can be given only at the expense of their principal responsibilities.

131. The proposed service should be independent of departments having regulating or other direct responsibilities in the field of radiological health and safety. It should also be independent of the Authority, since it may be called upon to advise in matters in which the Authority are concerned. For the service to be most effective it must be the servant of all but the agent of none.

132. In our view this aim would be more easily achieved if the proposed service were under the general direction of a senior Minister. We therefore suggest that the national radiological advisory service should be answerable to the Minister for Science, and that the Minister should consider establishing an advisory council (including representatives of both sides of industry) to assist him in his direction of the service.

Functions of the proposed new service

133. The principal functions of the proposed national radiological advisory service would be:

(i) to provide advice (for example, on the design of facilities and methods of health and safety control) and to provide services (for example, processing and interpretation of film badges) to:

(a) users of ionising radiations whose needs do not justify the employment full-time of highly qualified health and safety staff of their own, e.g. those firms, laboratories or hospitals using radioiotopes or x-ray apparatus as an incidental to their main business. There are about 3,000 concerns using apparatus which emits ionising radiations, rather more than half of which use x-ray apparatus;

(b) government departments without specific regulating responsibilities in this field (e.g. the Home Office and Ministry of Education); and services such as the police, fire and transport services;

(c) local authorities (particularly advice on the public health aspects of work involving ionising radiations in their areas);

(ii) to assist the departments which exercise statutory controls, and the Atomic Energy Authority, by relieving them of routine duties of advice and service, and by putting its knowledge and experience at the disposal of departments.

134. Another important function of the proposed organisation would be to provide help in an emergency. The Atomic Energy Authority and the electricity generating boards are largely self-sufficient in this matter. Nevertheless even they might welcome outside help following an accident. In the event of incidents elsewhere, the principal reassurance to the public would come from the availability of a service along the lines we propose. There have already been a number of relatively minor incidents and, in addition, a number of false alarms and hoaxes. In nearly every one of these, assistance has been sought from the Atomic Energy Authority, and this has been a burdensome addition to the calls on the Authority's resources.

135. The new organisation should be so constituted that emergencies could be dealt with promptly and authoritatively. It should be available to advise and help public services such as the police and transport authorities, who are usually the first to become involved; to provide a decontamination service; and to explain the true significance of incidents to local authorities and the public.

136. We can see no reason why the national radiological advisory service should conflict with the interests of those government departments which exercise statutory controls. Their responsibilities would remain, but the service should have the confidence of the regulating departments, and should accordingly be in a position to assist users of ionising radiations in the performance of their statutory duties. This would not relieve users of ionising radiations of these duties, nor of their responsibility for the safety of their own operations. Moreover the fund of practical knowledge accumulated by the service would be of great value to everyone concerned, including the regulating departments.

137. Finally, the proposed service could play a valuable part in training. If the service is to attain the status we consider necessary, it will need well-trained staff who could make a valuable contribution to teaching in courses organised by universities, technical colleges and other bodies. Indeed, this association with teaching, if coupled with research, would in itself be a valuable stimulus to the staff of the service.

The existing Radiological Protection Service

138. Before reaching conclusions on the form of a proposed national radiological advisory service, we reviewed the origin and functions of the existing Radiological Protection Service and considered how it differed from the organisation which we conceive to be necessary.

139. The Radiological Protection Service was established in 1953, by the Medical Research Council and the Ministry of Health jointly. Its purpose was to provide an advisory and monitoring service for the protection of workers and the public against radiation hazards. However, it was not concerned with workers in atomic energy establishments. The service conducts research on behalf of the Medical Research Council, and provides expert assistance for the Radioactive Substances Advisory Committee, to which the Director is technical secretary.

140. The Radiological Protection Service was thus set up by departments which combined research and hospital interests. In practice, a major proportion of its work is now undertaken on behalf of industry, and facilities are being developed increasingly by hospital boards to handle much of the routine hospital work.

141. The Radiological Protection Service has done excellent work, but the demands on its limited resources are now becoming unmanageable. The position of the Service is being reviewed, and we hope that our proposal (which is a development of the 1953 concept in the light of present and foreseeable needs) will be helpful. The Ministry of Health and the Medical Research Council are at the cross roads in considering the future of the service. The organisation we propose is designed to preserve the role of the Radiological Protection Service in relation to the Medical Research Council and the Radioactive Substances Advisory Committee while making it part of the new radiological advisory service.

Form of the proposed new service

142. For the national radiological advisory service to be effective it must be organised on a regional basis. Complete centralisation would defeat the

purpose of our proposal, because an intimate understanding of local problems and conditions, and being readily accessible, are prerequisites for a successful service. We therefore envisage a number of regional centres conveniently chosen in relation to universities, regional hospital boards, the regional organisation of government departments, and the distribution of industry. These centres should be coordinated to form a coherent national organisation, and the staff of each should be of the size and calibre for its advice to be acceptable as authoritative throughout the region. The work of giving routine advice and service would be undertaken by each of the regional centres, but it would probably not be necessary for some expensive equipment (e.g. that required for measurement of whole body burden) to be provided at each regional centre. The national headquarters would act as a centre for collecting and disseminating information and, as far as possible, would ensure common practice throughout the country.

143. The existing Radiological Protection Service would become part of the new service, and the organisation would then be as follows:

(a) The headquarters would serve both the Medical Research Council and the Radioactive Substances Advisory Committee, and its staff would conduct research in radiological protection.

(b) The headquarters would also act as a regional centre for the new service; much of the present routine work of the Radiological Protection Service would be diverted to the other regional centres as appropriate, but responsibility for such duties in a limited area, based on London, would provide a desirable amount of practical work and would assist the integration of the Radiological Protection Service and the new organisation.

144. For the proposed service to be of the necessary calibre, every centre would need to have close links with those directly concerned with research, and it is for consideration whether the regional laboratories should not themselves be centres of research. If so, their relationship with the Medical Research Council would be through the national headquarters (which would already be acting as a special Medical Research Council laboratory).

145. We have not developed our proposal beyond the outline given in the preceding paragraphs, as there are factors outside the scope of our remit which will need to be taken into account. We recognise that there are financial implications, but are nevertheless convinced that a national radiological advisory service is a necessity.

146. *We recommend the establishment of a national advisory service as outlined in this chapter.*

CHAPTER V

A NATIONAL TRAINING CENTRE

147. The third part of our remit from the Atomic Energy Authority was "to consider what steps should be taken by the Authority to establish a national training centre for health physics and nuclear safety staff". Whilst we agree with the Fleck Committee's view that the urgency of the situation might warrant special measures, we believe that we have interpreted the spirit of their views correctly as requiring a planned development of training in radiological health and safety, on a national scale, rather than the establishment of a single training centre at one geographical location.

148. In the preceding chapter we have outlined proposals for a regionalised advisory service, one of the main features of which is its daily contact with all kinds of people in its area. It must gain not only knowledge of the problems, but, equally important, the respect and confidence of everyone concerned. On this advisory service staff there would be fully competent people who would be well equipped to assist with the provision of courses in radiological health and safety in local colleges.

149. In universities and colleges there is a fund of the skill and enthusiasm so necessary for any successful training. The association of the advisory service staff with people skilled in training would clearly benefit both, and do much to ensure that those without training experience but with particular knowledge would be the better able to communicate their ideas.

150. We have found the universities and colleges responsive to the new opportunities in this field. We have held discussions with men of experience in the educational field, representing a good cross-section, both geographically and at various educational levels. They convinced us that the existing educational facilities are capable of being expanded to cover the new need. Moreover, this expansion can be regulated in accordance with the rate of growth and the geographical incidence of the demand. Since a good deal of health and safety training must of necessity involve release from employment, the established procedures for the attendance of trainees at sandwich or other courses can satisfactorily be applied in this new subject as in many others. New opportunities for strengthening the links between industry and, in particular, technical colleges are constantly arising as new technologies develop; radiological health and safety should be no exception.

151. For training to be given in one centre, a staff of the highest calibre, from the scientific, technical and educational points of view, would have to be assembled. This would involve people who are making valuable contributions in rapidly expanding and diverse fields of science, medicine and technology, and who would insist on continuing to be able to do so. The creation of such a national training centre would be more analogous to setting up a complete new university than a single department. In addition, technical training would have to be provided over a very wide range. The centre would have to

form a fairly tightly knit community for periods of weeks at a time, and this would entail the extensive provision of hostels, recreational facilities and other amenities—a costly business which again duplicates much that is being done in existing colleges.

152. It would, we think, be a retrograde step to propose the setting up of an educational establishment concerned exclusively with radiological health and safety. Moreover, to do so would be to concentrate the teaching geographically in a way which would be inconsistent with the practice of radiological health and safety throughout the length and breadth of the land.

153. We must make the fullest possible use of the fund of skill and enthusiasm in training which is already available in universities and colleges. They may be short-staffed, and what we are proposing may be an additional load, but the numbers concerned are small relative to the total demand on the universities and colleges. Moreover, by locating the training in the existing institutions, the knowledge which we are convinced should be widespread will be quickly and effectively disseminated in those areas where the need is greatest, with the minimum of disturbance to the national resources both of manpower and facilities.

154. While we feel the need for a national training policy, we are convinced that the most satisfactory results would be achieved by using to the full existing facilities at all levels.

155. *We recommend that the Authority should not establish a national training centre.*

CHAPTER VI

TRAINING FOR FULL-TIME HEALTH AND SAFETY STAFF

156. In this chapter we discuss first the training for what we described in Chapter II as safeguards work; then the training required for categories A, B and C for radiological protection work. In doing so, our aims are to state the objectives and put forward the principles which should in our view govern the training of radiological health and safety staff, rather than to produce a detailed blueprint for a national training scheme.

157. The duties of full-time health and safety staff described in Chapter III call for diverse kinds of specialised knowledge; not one of the existing academic disciplines would by itself offer a complete preparation for them. Also in order to bring into this field men of high calibre it is necessary to provide scientific and technical training at the highest academic levels. This training must include new kinds of courses overlapping a number of the traditional disciplines such as physics, chemistry, biology and medicine.

158. It is clear from the descriptions of radiological protection and safeguards work respectively, given in Chapter II, that these two broad types of work require very different qualifications and training. Apart from exercising direct control of radiation hazards, radiological protection staff advise safeguards staff on the standards of human protection to be applied in the assessment of the safety of nuclear installations. Radiological protection staff need a specialised training which overlaps the boundaries of physics, chemistry, biology and medicine. Safeguards staff on the other hand are primarily specialists in the applied sciences and mathematics. They need some knowledge of health physics, and in addition sound judgement, experience and tact.

Training for safeguards staff

159. The safeguards worker is basically a specialist in a traditional discipline, and requires in addition to his academic qualifications a certain amount of further training of a formal kind, as well as experience in the field. The former can be given by means of existing courses, and experience can best be obtained by working as part of a team engaged in the safety assessment of a nuclear installation. A memorandum on the training of safeguards staff, including a list of the courses which have been used, is given at Appendix C.

160. *We recommend that the existing provision for formal training of safeguards staff be accepted as adequate.*

Training for radiological protection staff

161. Before discussing the training required in radiological protection, we collected information on the nature and volume of the possible demand and on the existing courses. We then considered whether existing training facilities could meet the demand, to what extent new courses were needed, and by whom

they could best be provided. Besides the content of the training courses, a number of other considerations had to be borne in mind—such as the sources of students, the means of financing the proposed training, and the need for a recognised qualification or award at the end of a course.

Category A

162. A fundamental need is to attract a proportion of the most capable graduates to undertake postgraduate study and research related to radiological health and safety. We have for convenience described these as "category A". They will be expected ultimately to be capable of assuming higher managerial responsibilities in this field, or of playing a leading role in the scientific development of the subject. In view of the acute shortage of such people, of the importance of their work, and of the extensive training required, we decided that our first task must be to study this category. We submitted an interim report to the Authority in January, 1959, so that some preliminary action on this urgent problem could be taken in advance of our final report. In drawing up our interim report we had the benefit of informal consultation between individual members of the committee and the heads of interested university departments, as well as with senior university administrators. We also received much helpful information and advice from the university appointments boards.

163. In our interim report we took the view that it was appropriate that postgraduate work of this quality should lead to an M.Sc. or Ph.D. The range of subjects to be covered meant that the planning and provision of courses involved several faculties and departments. Courses were already established in London University (a two- or three-year course, generously financed by British electrical industry, at the Institute of Cancer Research, Royal Cancer Hospital, leading to an M.Sc. or Ph.D. in biophysics; and a two-year M.Sc. course in radiation physics, run jointly by The Middlesex Hospital Medical School and St. Bartholomew's Hospital Medical College). In addition, research could be undertaken in these three centres and in the universities of Cambridge, Edinburgh and Leeds, but the majority of United Kingdom universities had no existing facilities which could readily be adapted at short notice to meet the demand.

164. An expansion of appropriate studies at the postgraduate level was in our view called for, but we considered that it should be confined in the first place to a few universities, thus making the best use of the limited tutorial and research facilities available. We prepared an outline syllabus for such courses of study, leading to a postgraduate degree in radiological physics (see Appendix E). This syllabus (based on previous experience at the Institute of Cancer Research) indicates only what we regard as the essentials of the subject and leaves the details to be worked out. The differing initial qualifications of the students (medicine, physics, chemistry, biology, and perhaps engineering) present some difficulty. The courses have to be so organised that each student receives special instruction in subjects other than his own, thus enabling him to profit from the course as a whole.

165. We recommended to the Authority in our interim report that they should promote the establishment of postgraduate courses of this type, if possible in time for the 1959-60 academic year. We thought that an annual intake of

twenty students would make a worthwhile contribution to the solution of the national problem of providing high grade specialists without risk of over-provision. Since most of the students were likely to need grants to finance their training we recommended that the Department of Scientific and Industrial Research (which is the recognised government agency in these matters) should be invited to extend the range of their scheme of grants to include the proposed courses. Our interim report was accepted by the Authority in February, 1959.

166. The Department of Scientific and Industrial Research agreed to consider sympathetically applications for advanced course studentships[1] for the purpose of attending university courses accepted by the Department. Sufficient studentships could be awarded without any addition to the Department's budget. Students who wished, after doing a two-year M.Sc. course, to continue for another year for a Ph.D., would be considered by the Department for research studentships, which are not given for formal courses of instruction.

167. The Medical Research Council also give grants for training in research methods. We were assured that well qualified students in science or medicine wishing to take a Ph.D. in radiobiology or radiological physics would be considered sympathetically for grants.

168. By February, 1959, the date by which the Department of Scientific and Industrial Research required to have courses submitted for acceptance was already past; but they fully appreciated the importance of not losing a whole academic year, and agreed to receive late applications from universities proposing to start courses such as we recommended. Applications were made by Birmingham and Edinburgh Universities, and also, in respect of their existing courses, by the three London University schools. The London and Birmingham courses were accepted, but consideration of the University of Edinburgh's application was deferred when it became clear that the first course could not be started in the autumn of 1959.

169. We knew that in the middle of a quinquennium the University Grants Committee were not likely to have funds available for giving substantial aid for developments which had not already been included in their budget. However, Birmingham University required considerable grants, both for capital expenditure on new buildings and equipment, and for additional current expenditure, and Edinburgh University needed capital for building. The University Grants Committee were extremely helpful, and approved the two schemes in principle. They then discussed the detailed requirements urgently with the two universities, in the hope that the courses might be started in the autumn of 1959. Time was however very short, and Edinburgh University were obliged to postpone the introduction of their course until the autumn of 1960.

170. An M.Sc. course of twelve months was started in September, 1959, in the Faculties of Science and Medicine at Birmingham University (particulars of the course are shown at Appendix F). Five students enrolled for this course (two with D.S.I.R. studentships) though the University had been unable to advertise it until July, 1959. The intake may reasonably be expected to be higher

[1] Advanced course studentships are given for periods of up to two years, and can lead to an M.Sc. in a one-year or two-year course, or to a postgraduate diploma; these studentships are not primarily for research, but for advanced instruction in which research may play a part.

next year. After completing the M.Sc. course, suitably qualified students may proceed to a Ph.D. after a minimum of two further years' study and research.

171. Edinburgh University's plans are well advanced for a one-year course, starting in the 1960-61 session, for a diploma in biophysics. After obtaining the diploma, students will be able to register for a Ph.D.

172. In addition, there has been an increase in the number of students in the Institute of Cancer Research who are reading for higher degrees in biophysics of the University of London; the present number of students is fifteen (thirteen for Ph.D., two for M.Sc.), an increase of five compared with the previous year. The numbers also appear likely to grow in the course run jointly by The Middlesex Hospital Medical School and St. Bartholomew's Hospital Medical College, which in September, 1959, had sixteen students (of whom ten were part-time).

173. We are advised that the optimum number of students for a postgraduate course is between ten and fifteen at one centre, and therefore

we consider that the existing and projected university postgraduate courses will be adequate, when fully developed, to meet the estimated demand (including some small allowance for wastage).

174. *We recommend that category A courses should be regarded for the time being as appropriately given in universities without prejudice to possible later developments in colleges of advanced technology; that the courses should be on the lines of the outline syllabus at Appendix E; and that they should normally lead to an M.Sc. or Ph.D. degree.*

175. *We recommend that, in addition, other universities with research schools should be encouraged to accept each year a small number of students for postgraduate degrees in disciplines relevant to radiological health and safety.*

Category B

176. We next considered the training appropriate for the staff described in Chapter II as category B, whose minimum basic qualifications should be a pass degree, or a Higher National Diploma or Higher National Certificate, in science or in engineering.

177. We prepared a specimen syllabus for this category, which we have been advised should be within the scope of a college of advanced technology (though no such courses are yet available). This syllabus, with an explanatory note, is given at Appendix G. In drawing up the syllabus, we had the opportunity of comparing our ideas with the practical experiment carried out at the Reactor School at Harwell, where the Authority ran an advanced course in the principles of radiation protection, from October, 1959, to January, 1960. This course was primarily for their own radiological protection staff, but was also attended by a few people from educational institutions and from industry. The course aimed at a high academic standard and was intended to be suitable for graduates (including graduates in medicine) starting work in radiological health and safety, and for those already working or teaching in the field. It covered a wide range of fundamental background knowledge and dealt with principles rather than techniques; about forty-five lectures were devoted to basic scientific principles, thirty-five to principles of radiation protection, and ten to general topics, while a considerable amount of practical work and a

number of visits were included. A second course is being held, from 20th April to 20th June, 1960.

178. The course which we propose is intended to last either three months or a year. The three months' course would be suitable for students who, in addition to their basic qualifications, have had some practical experience in a field of science or technology. Those who are already in employment and who are transferring to radiological health and safety duties require a sound training in the fundamental principles of radiological protection, as well as in methods of dealing with practical problems. In suggesting that the course might be concentrated into three months, we had it very much in mind that few employers would wish to release such staff for longer.

179. A one-year course covering the same ground, additional time being given for laboratory work and for training in methods of dealing with practical problems, would suit students with the requisite academic qualifications but without practical experience. We consider that a one-year category B course would therefore be particularly appropriate for students newly qualified at degree or Higher National Diploma level.

180. Sandwich courses should also be considered, as this arrangement would have considerable attractions for employers as well as for the students.

181. Courses of all three types could most appropriately be given at colleges of advanced technology. Courses in these colleges are intended to be complementary to those in the universities. They have in common the aim of dealing with basic principles and their application, but the colleges of advanced technology have a closer association with industrial applications. They can therefore adjust their courses to meet the needs of organisations concerned with developments in nuclear engineering, the use of radioisotopes, and the use of ionising radiations.

182. It is not appropriate for us to recommend where such courses should be set up, but we would mention the following considerations. The relatively small annual demand, the cost of providing courses of this kind, and the need for them to be viable, all point to concentration in a small number of centres. In selecting the most appropriate colleges, many factors will have to be taken into account: the existing accommodation, staff, equipment and experience of the colleges; their proximity to universities, teaching hospitals or nuclear installations, from which part-time lecturers might be found and where visits might be arranged for students; their proximity to large sources of demand; and—since students will necessarily be drawn from all over the country and even from overseas—the residential facilities available.

183. We are advised that the optimum number of students for a course is about fifteen. A college providing a three months' course could in theory run three courses a year, with an output of forty-five, which would probably be more than sufficient, if there were no wastage, to meet the annual demand for the whole country. However, we believe that in practice, it would be preferable to have courses at more than one college, which would afford greater flexibility.

184. We regard the one-year course as very desirable, and consider that three months is a short time to cover the ground unless students have already had some practical experience. A three months' course based on our syllabus will

have to be very intensive. Nevertheless we think that priority should be given to the setting up of three-month, rather than one-year, courses, because the demand, at any rate at first, will be mainly from industry-based students, who are not likely to be released for longer than three months, especially for an unproven course.

185. *We recommend that category B courses, lasting either three months (primarily for those already in employment) or one year (primarily for new graduates), on the lines suggested in Appendix G, be set up at colleges of advanced technology, priority being given to the three months' courses.*

186. *We recommend that consideration be given to setting up one of these category B courses at a college in Scotland, particularly in view of the existence of three major nuclear installations in Scotland.*

187. The Ministry of Education for Northern Ireland do not consider that at present the demand justifies the establishment of category B courses in Northern Ireland.

188. We have also considered whether a diploma or certificate could be given to those successfully completing such courses. Courses approved by the National Council for Technological Awards lead to the nationally recognised Diploma in Technology. There is also a proposal under consideration by the National Council for Technological Awards for a more advanced award (M.C.T.)[1]. The proposed courses in radiobiology and radiological physics do not however fit into schemes for these awards.

189. *We recommend that students who successfully complete category B courses at colleges of advanced technology should be awarded appropriate college diplomas.*

Category C

190. In this category are supporting staff who normally have technical but not professional qualifications. They are concerned with many aspects of radiological protection, and their work requires a high degree of practical competence. The training necessary consists of instruction on the intelligent use of instruments; on the operations going on in an installation (especially those parts of the operations where radiations or radioactive contamination are present); on the properties of radiations and the principles of the measuring instruments used; and on the general aspects of the biological effects of radiations and the permitted levels of exposure. This basic instruction can be provided by many technical colleges using existing staff and equipment, provided advice is given on the content of the course.

191. Such courses will be of much shorter duration than we have recommended for categories A and B. The outline syllabus in Appendix H is intended for students who are already employed in this field and is based on the course for health physics monitors held at the Atomic Energy Research Establishment.

192. *We recommend that courses on the lines of Appendix H should be provided either as full-time courses, or as day release courses, at technical colleges or at places of employment if no suitable technical college is available.*

[1] Member of the College of Technologists.

193. We have discussed with the City and Guilds of London Institute whether the Institute would be prepared to adopt such a scheme. If so the Institute would control the content of the courses, the syllabus, and examinations; students successfully completing the courses would receive a certificate of the Institute, which would become a nationally recognised award. The Institute have expressed their willingness to set up an exploratory committee to study the question of a City and Guilds certificated course in radiological protection; and we understand that the British Employers' Confederation, the Trades Union Congress and the Central Electricity Generating Board (as one of the major employers) support this proposal.

194. If such a scheme is to be introduced for the 1961/62 session, it is advisable for steps to be taken by May or June, 1960, to set up the exploratory committee. This would enable the necessary deliberations to take place and authorisations to be completed in time to give the colleges adequate notice and information.

195. *We recommend that the City and Guilds of London Institute should be invited to take immediate steps to set up an exploratory committee to consider the introduction of a City and Guilds course, at technical college level, in radiological protection.*

CHAPTER VII

BACKGROUND TRAINING

196. We drew attention in Chapter I to the fact that, apart from courses for those engaged full-time on radiological health and safety duties, education in radiological problems is required over a wide field of industry and the public service. Needs will differ in this field. The Fleck Report on the Organisation for Control of Health and Safety in the United Kingdom Atomic Energy Authority[1] stated that medical officers of health and their senior medical staff should understand radiological hazards and the methods of checking levels of radiation and radioactive contamination, that inspectors of factories and sanitary and water engineers would require similar knowledge, and that other people such as industrial nurses and the police should also be given basic instruction in the subject. The report added that these were no more than examples illustrating the size of the problem.

197. We referred in Chapter III (paragraph 102) to the need for education in safe practices of employees of the Authority, and particularly those with operational responsibilities. This applies equally to other organisations such as the electricity boards and the consortia. Background training is therefore needed by large numbers of people employed in the atomic energy industry in operations and in research, and instruction in health and safety is a necessary element in scientific and technical training courses dealing with any aspect of nuclear energy or ionising radiations. We have found this to be the case in all the courses we have considered, and no further development of this aspect of the problem appears to us to be required.

198. In the light of the information collected on training requirements, we concluded that, in addition to the professional and semi-professional classes referred to in the Fleck Report, many of those engaged in administration and management also needed background training. Moreover, special consideration had to be given to the medical profession as a whole, and there was a pressing need for the general public to be given more information about radiological health and safety. As the Fleck Committee recognised[2], it is "of the first importance that the hazards of atomic energy should neither be exaggerated nor minimised in the public mind".

199. In this chapter we discuss the need for background training under the following heads:

(a) training for administrators, managers, medical officers of health and other professional workers having a particular concern with radiological health and safety;

(b) training for subordinate staff of local and public authorities, and of services such as the police and fire services;

[1] Cmnd. 342 (H.M.S.O. 1958)—paragraph 98.

[2] Ibid—paragraph 4.

(c) training for the remainder of the medical profession;

(d) information for the general public.

These are not watertight compartments, however; there will have to be flexibility in meeting these needs and there will undoubtedly be opportunities for combining two or more classes.

200. We have prepared a framework for background training (Appendix I) which includes instruction in radiological hazards and protective measures.

Training courses for administrators, managers, medical officers of health and other professional workers

201. In Chapter VI we were concerned with the training of those who carry full-time responsibilities in the field of health and safety. We regard as equally important the training of those with responsibility for related administration and management. These may be called upon to take difficult and far-reaching decisions—particular in the event of an emergency—or to give advice upon which such decisions are taken. Their importance was emphasised by Sir Alexander Fleck in his address to the summer school at Oxford (see paragraphs 202-204 below) on 31st July, 1959. After recalling that health and safety policy in all fields, not only the radiation field, was determined by social conscience, apprehension in the face of real or imagined danger, and economic considerations—which, he pointed out, did not always favour laxity by any means—he said:

> "... the judgements which have to be made are essentially human ones, not scientific ... Those with managerial experience know full well that important decisions frequently have to be taken before all the relevant evidence is available, and indeed it is one of the marks of the good administrator that he should be able to display sound judgement in such situations".

The administrative issues may often be more perplexing than the technical ones. We therefore attach importance to adequate background training for those who, while not being specialists in radiological health and safety, have to be able to take related policy and managerial decisions.

202. With the approval of the Authority, we asked the Oxford Extra-Mural Delegacy to organise, with the assistance of the Authority, a pilot course for administrative and managerial staff at Oxford during the long vacation of 1959. The content of the course, which lasted a fortnight, covered a wide field, and lectures were given by a distinguished panel of speakers.

203. The course was attended by senior civil servants, medical officers of health, officers of the three Services, managerial and executive staff from industry (nationalised and private), water engineers, river board officers and a trade union official. We were thus able to include some of the groups referred to in the Fleck Report (see paragraph 196 above). It was generally agreed by the participants that a course of this kind met their varying needs, and that separate courses for different occupational groups were not desirable. A mixed school was considered an advantage; the varied background and professional

interests of the participants added to the value of the discussion sessions and the after-lecture questions.

204. At the closing forum, those who had attended the course were unanimous in thinking that it had been valuable, and had given the background which they had previously lacked. They saw no substitute for the course in the reading of books, even if suitable books existed.

205. The syllabus of the course is given in Appendix J.[1] We should like to record our appreciation of the great help given to us by the Delegacy.

206. We are pleased to see that advanced courses of background training have already been arranged by The Middlesex Hospital Medical School and the Imperial College of Science and Technology, and will take place respectively in the spring and summer of 1960. (See Appendix D).

207. *We recommend that further courses of background training for mixed groups of administrators, managers and professional workers should be provided by university extra-mural boards or colleges. The demand is so great, that for some years any course which can be properly organised is likely to be fully taken up.*

Background training at less advanced levels

208. Simpler forms of training will be suitable for those with more limited responsibilities, e.g. subordinate staffs of local health authorities, public health inspectors, the police and fire services, nurses, and ambulance workers. The needs of these groups differ, but, in general, simple instruction is needed on the nature of the hazards; how to judge the need for expert help; and the precautions to be taken until help arrives.

209. For the hospital, police and fire services this training should, in our view, be included in the normal training programme for new entrants and, where applicable, in continuation training for those already in post.

210. Where the employer's training programme does not cover the need, we suggest that suitable courses should be arranged locally, possibly by the local authority, the regional hospital board, or the local education authority.

The medical profession

211. We referred to the needs of medical officers of health in Chapter III (paragraph 81) and consider that, in principle, these can best be met by the type of course described in paragraphs 202 and 203 above. While we realise that it may be difficult for medical officers of health to attend courses of this duration, we are convinced that the ground cannot be adequately covered in a shorter period.

212. These suggestions apply to medical officers of health already in post. But in the long run all medical officers of health must receive instruction in radiological health and safety as a normal part of their professional training, and

[1] *Note.* Colleges or university extra-mural boards which may decide to mount similar courses can be provided with additional information about the course by the Health and Safety Branch, U.K. Atomic Energy Authority, 11 Charles II Street, London, S.W.1.

eventually the Ministry of Health should require all medical officers of health to have received such training.

213. *We recommend that:*

(a) *the curriculum for the Diploma in Public Health should include a course of instruction in radiological health and safety;*

(b) *the regulations governing the Diploma in Public Health, when next revised by the appropriate Special Committee of the General Medical Council, should make specific reference to instruction in radiological health and safety.*

214. We have taken advice on the extent to which the study of the effects of radiations should be included in the basic medical curriculum leading to the first qualifying medical degree. This curriculum is already overloaded, and it is not easy for medical schools to introduce additional subjects. Nevertheless, the subject is sufficiently important to merit instruction being included. We note that some medical schools are already including it.

215. *We recommend that the medical schools consider the desirability of including in the basic medical curriculum some instruction in the use and hazards of ionising radiations; this instruction need not be elaborate, but should give a clear picture of the scientific principles involved and the significance of the effects.*

216. The general practitioner may be asked questions about radiation hazards and effects by his patients. He should know when he must call in expert help or specialist opinion. General practitioners should be encouraged to attend any of the various types of course discussed earlier in this chapter, particularly if they practise in the neighbourhood of a nuclear installation or a factory making extensive use of radioactive materials. The established general practitioner should be kept up-to-date by articles in the medical press. Suitable lectures might well be organised by local branches of the British Medical Association.

General public information

217. So far we have been mainly concerned with formal instruction by means of lecture courses at widely different levels. Lectures can also be a useful method of informing the general public, but there are other forms of communication which can and should be used for this purpose, e.g. newspapers and periodicals, books, films, exhibitions, radio and television. (Some of these can also play a part in more formal training).

Lectures

218. It has already been suggested that occasional lectures or symposia might be organised for doctors by local branches of the British Medical Association. Lectures for the public could also be arranged by the British Association for the Advancement of Science. Such a project would be fully in keeping with the British Association's revised constitution and policy; if the projected local branches framed their own programmes of scientific lectures, discussions and study groups, these would be ideal for the purpose we have in mind. Other

possibilities are that suitable lectures might be arranged by university extra-mural boards, technical colleges, residential colleges and voluntary organisations. There is however a limit to the uumbers that can be reached by public lectures; this limit is imposed by the scarcity of qualified lecturers and the time they can devote to lecturing, and by the size of audiences. If, however, they are well publicised, so that a good audience is attracted, the public lecture has much to commend it; people who take the trouble to attend a public lecture usually make good use of what they hear.

Exhibitions

219. Exhibitions, especially if models and demonstrations are included, are another useful way of couveying information. Admittedly, for a subject of this nature they tend to be expensive of manpower because they require manning by specialists if they are to be fully effective, but on the other hand they provide an admirable focus for other information techniques such as lectures, the showing of films and the dissemination of written material.

Books

220. There is a real need for a book written for the layman, and dealing comprehensively and objectively with radiological health and safety. Many participants at the Oxford conference felt that a book of this kind was very much needed. They thought it would serve both as useful preparatory reading and as an aide-memoire for those who were able to attend background courses; it would also be of value to interested readers who could not attend a course, but they did not regard reading as a substitute for a course for those with a real "need to know" as distinct from an intelligent lay interest in the subject.

221. *We recommend that the Authority should explore the practicability of getting suitable books or pamphlets on radiological health and safety published for the non-specialist reader; they might be comparable in content to the framework for background training (Appendix I) or the Oxford conference (Appendix J).*

222. The desirability of occasional authoritative articles, by recognised experts, in the medical press has already been referred to. Scientific, professional and industrial publications in other fields are also an excellent medium for the dissemination of information to an interested public.

Films

223. The Authority have made a number of films[1], and these are in frequent demand for loan to such bodies as universities, technical colleges and schools. We think that films can play a most useful part in public information; as adjuncts to training (members of the conference at Oxford all agreed that they would have liked more films in the course if suitable films had been available); and in some cases as a substitute for lectures. Suitably made films could be used for training outside the Authority, would lighten the demand for lecturers, and would be particularly useful, for example, for local courses of background training for subordinate staff of local authorities.

[1] List in Appendix K.

224. *We recommend that films on radiological health and safety be made both for public information and as an adjunct to training; and that the Authority should, in consultation with interested government departments and with private and nationalised industry, work out a programme for the production of suitable films.*

Radio and television

225. Radio and television programmes are another effective means of giving the public a clearer idea of the meaning of radiation hazards and what is done to safeguard against them. Although participation in such programmes imposes an additional burden on the present small number of health and safety specialists we believe it is well worth-while.

226. *We recommend that the Authority and other bodies should, whenever possible, co-operate with radio and television organisations in the production of programmes designed to give the public a clearer idea of radiation hazards and the means by which they are controlled.*

CHAPTER VIII

THE ROLE OF THE U.K. ATOMIC ENERGY AUTHORITY

227. The United Kingdom Atomic Energy Authority were established in 1954 to assume responsibility for the production, use and disposal of atomic energy and to carry out or promote related research. The object of the transfer of responsibility from the Ministry of Supply was to introduce a form of control more akin to the structure of a big industrial organisation than that of a government department, and to facilitate closer contact and co-operation with industry. The Authority were empowered to ". . . educate and train persons in matters connected with atomic energy or radioactive substances".

228. The organisation and work of the Authority are described in Chapter III (paragraph 94). The Authority policy has been to recruit good scientists and engineers without necessarily requiring them to have any knowledge of the special techniques of atomic energy work. The training programme has enabled recruits to learn these techniques by doing the job and by attending lectures and colloquia. In addition specialised training of a formal kind is available.

Training of Authority staff

229. The Authority, besides making full use of the national education system, provide for their employees vocational training courses (especially for new recruits), such as general induction; techniques for process workers; laboratory techniques; instrumentation; radiochemical techniques; reactor engineering; radioactive contamination; and management. All these contain some reference to health and safety.

230. In addition the following training is provided for full-time health and safety staff: a two-week course in health physics for monitoring personnel; and a course for graduate recruits consisting of selected parts of Authority courses supplemented by existing courses elsewhere (e.g. the two-week course on radiation safety and health physics organised in co-operation with the Authority by the Liverpool College of Technology (see Appendix D)) together with special lectures, seminars and tutorials by health and safety staff, selected reading and experimental work. Staff so trained then gain practical experience in health and safety duties by working under supervision.

231. To meet the immediate need to give specialised training at an advanced level in fundamental radiological physics and radiobiology, a trial course of lectures, practical work and visits to installations was held at the Atomic Energy Research Establishment, Harwell, from October, 1959, until January, 1960. The lecturers were mainly Authority staff, but valuable contributions were included from the staff of the Agricultural Research Council, the Institute of Cancer Research, the Medical Research Council, the Ministry of Housing and Local Government and the Radiological Protection Service. A

second course, modified in the light of the experience gained from this trial course, will start in April, 1960.

232. Closely allied to training is the need for the interchange of ideas between health and safety staff and scientists and engineers working on similar problems. The Authority have arranged conferences on health and safety topics, both on their own account and in co-operation with the Agricultural Research Council and the Medical Research Council; and lectures and colloquia on research and operational problems.

233. To meet the need for other specialised training both of their own staff and of those in industry in this country and abroad, the Authority conduct three schools. The courses at these schools all contain an element of instruction in the problems of radiological health and safety, but few of the courses give specialised training in the subject.

Training—general

234. The first school was set up in 1951 at the Atomic Energy Research Establishment, Harwell, to give training in the use and measurement of radioisotopes and the health and safety precautions that should be taken. The standard course in the Isotope School lasts four weeks, but a number of other courses have been introduced for specific purposes. The increasing use of radioisotopes by industry led to numerous requests for advice on the problems of safe handling and disposal of radioisotopes To meet this need short courses, of five days' duration, were started in 1955.

235. When industry undertook the task of designing and constructing nuclear power stations they were confronted with the problem of training staff as rapidly as possible in reactor theory and technology. In 1954 the Authority therefore set up a Reactor School at Harwell. The course occupies sixteen weeks, of which the first six weeks are now taken in colleges of advanced technology. The main subjects taught are reactor engineering and reactor physics; lectures on health physics are given as a background to these subjects.

236. Training in the operation of power reactors is given at the Calder Operation School, which was founded in 1957. The courses last five weeks, of which health physics and safety form a small part. In addition a two weeks' course on health physics is conducted at Windscale. This course gives a background knowledge of the health physics relevant to the operation of nuclear power reactors.

237. The Authority have also paid careful attention to the dissemination of information on all aspects of atomic energy, including radiological health and safety, by organising conferences; encouraging their staff to publish the results of their work; providing information services; and helping with courses in universities, colleges of advanced technology and technical colleges. Their staff have also given lectures, written articles for newspapers, magazines and professional journals, and broadcast by radio and television. Arrangements are made to keep the Press regularly informed of the work and progress of the Authority. Information is also presented to the public by exhibitions and educational films (see Appendix K); one of these films, "Criticality", made primarily for training employees in the safety precautions to be taken when

working with fissile material, has won a number of scientific film awards in this country and abroad.

238. In the international sphere the Authority have organised courses in radiological protection, lasting two to three weeks, for the International Labour Office and the World Health Organisation.

The Authority's future contribution to training

239. In the long term, basic instruction in radiological health and safety should be provided as far as possible by the established educational institutions. While health and safety courses may have to be conducted by the Authority for the training of their own employees and others for whom they have undertaken an obligation, the various types of health and safety courses that we have proposed can in general be provided by the universities, colleges of advanced technology and technical colleges.

240. *We recommend that the Authority should not provide general courses which can equally well be made available in universities, colleges of advanced technology and technical colleges.*

241. On the other hand, by carrying out research on atomic energy and in virtue of their experience in the operation of novel installations, the Authority acquire unique knowledge in certain fields. We have in mind also that it is in the Authority's own interests to continue their training activities, in view of the mutual advantages gained by contact between their own staff lecturing on their own specialist subjects, and those concerned with health and safety duties elsewhere.

242. *We recommend that the Authority should continue to provide specialised courses and to arrange colloquia and conferences of a kind which cannot readily be provided in universities, colleges of advanced technology and other educational institutions.*

243. The fees for Authority schools are considerably greater than those for similar courses in universities, colleges of advanced technology and technical colleges. This is because the Authority have to cover the cost of running the courses, whereas the fees charged elsewhere are subsidised. In general we consider that this difference in fees should be maintained. In those cases where the Authority provide courses which cannot be made available elsewhere, however, we consider that the unsubsidised fees charged may turn away genuine students.

244. Other contributions which the Authority can make are:

(a) assisting universities, colleges of advanced technology and technical colleges to provide courses in radiological health and safety of interest to the atomic energy programme by giving specialist advice on the contents of the courses and supplying specialist lecturers;

(b) encouraging their staff to play a part in the writing of authoritative books, of which there is at present a dearth (see Chapter VII), and to publish the results of their researches and technological experience.

245. Active assistance by the Authority in these ways and the ways suggested in Chapter VII presents a formidable task. The help given cannot be allowed to take precedence over the primary responsibilities of health and safety specialists employed by the Authority. The first call on their time must continue to be the provision within the Authority of advice to ensure that no one suffers hurt or damage from the operations of the Authority's establishments. The Authority should therefore aim to recruit sufficient health and safety specialists, both in numbers and quality, to enable them to provide the leadership implied by the wider (though, in the last resort, secondary) responsibilities we have defined above.

CHAPTER IX

RECRUITMENT AND RETENTION OF TRAINED STAFF

246. Previous chapters have been largely concerned with the nature and scale of the demand for training in radiological health and safety, and with the kinds of courses which are needed. But the provision of courses will not of itself build up the nation's supply of radiological health and safety specialists. Students, sufficient in numbers and in quality, must be attracted to attend courses, and grants must be available for them. It is also necessary to ensure that, so far as possible, people who have completed courses are attracted into posts in the health and safety field and are not lost at that stage to other employment. Conditions are also needed which will retain well qualified people in this field, and will offer them worthwhile career prospects. Clearly, these problems are closely related; they are considered separately for convenience.

247. Inducements to potential recruits to this field, however, should not be such as to place disproportionate emphasis on the requirements of radiological health and safety as compared with those of other branches of science and technology which are also short of recuits.

Students

248. If a steady flow of able students with appropriate basic qualifications is to be attracted to courses in radiological health and safety, they must first of all be made aware of the subject and have reason to think it interesting and useful. They must be satisfied that courses are good of their kind; that the institutions and teaching staffs have a high reputation; that the courses lead to reputable qualifications; that adequate grants can be obtained; and that career prospects are encouraging. All these conditions must be satisfied from the very start. It is for these reasons that in preceeding chapters we have emphasized the importance of limiting the number of teaching centres in the first instance; of avoiding any risk of over-provision; and of setting up broadly-based rather than narrowly specialised courses.

Grants and studentships

249. The normal source of studentships for postgraduate courses at universities and category B courses in colleges of advanced technology is the Department of Scientific and Industrial Research. As explained in Chapter VI, the Department have already awarded advanced course studentships for students taking M.Sc. courses in radiobiology and radiological physics, and it seems probable that they could provide as many studentships as would be required. The Department and the Medical Research Council are also able to award studentships for candidates of merit, to undertake postgraduate research in universities. Category C courses at technical colleges will normally be attended by works-based students, with the approval and support of their employers.

250. We considered a suggestion that *open* fellowships might be given by the Atomic Energy Authority similar to those awarded by the United States Atomic Energy Commission. These fellowships are given to candidates not employed by the Commission, to enable them to study health physics for a year; no obligation in respect of employment is incurred either by the Commission or the candidates. We did not think such a scheme necessary in this country, since the need is already provided for by the studentships and grants available from D.S.I.R.[1] and the Medical Research Council.

251. We also rejected the idea of *closed* fellowships offered by the Authority in order to pre-empt staff for themselves. In the first place, if the Authority were to recruit new employees with the declared object of sending them on full pay on external courses, they would be better off than students on D.S.I.R. grants, though both would have been financed from public funds for the purpose. Moreover these Authority-sponsored students would not already have proved themselves in the Authority's employment, and might not return to the Authority on completion of the course; and there is no effective way of enforcing this.

252. However, we would endorse a proposal by any employer to send his established employees to attend courses at a university or a college of advanced technology.

253. *We recommend that the normal D.S.I.R. machinery for the provision of grants for students at universities and colleges of advanced technology should be used, and that no special scheme of grants to recruits is necessary or desirable for courses in radiological health and safety; we would however favour schemes made by employers to enable suitable established members of their staffs to attend such courses.*[2]

Recruitment and retention of health and safety staff

254. The experience of the United States Atomic Energy Commission suggests that a fair proportion of students, after completing postgraduate courses in radiological health and safety, will take up employment in other fields, inside or outside the atomic energy industry. Though their training may not, from a national point of view, be altogether lost, this wastage is undesirable while the present shortage of health and safety specialists persists. We note however that the Authority as a matter of normal practice keep in close touch with the universities with a view to attracting promising students for employment at the end of their studies (subject to satisfactory examination results).

255. *We recommend that special steps should be taken by the Authority and other employers to retain in the health and safety field successful students from the new courses we propose at category A and B level.*

Salaries and conditions of employment

256. To attract well qualified workers into health and safety posts, it is essential to offer them competitive salaries, promising career prospects, and interesting and satisfying work. We have noted, for example, that the recruitment of hospital physicists was satisfactory so long as their salary standards were comparable with those in the scientific Civil Service

[1]Particulars are given in D.S.I.R. Studentships and Fellowships (H.M.S.O. 1960).

[2]It is open to students who are not eligible for D.S.I.R. studentships, or are not financially supported by their employers, to apply to their local education authorities for assistance.

and the Authority. Their salaries are now relatively unfavourable, and wastage is considerable and recruitment insufficient. We think this is regrettable. We have already emphasised in Chapter III (paragraph 87) the importance of an adequate supply of well qualified hospital physicists.

257. We also noted a part of the Authority's own health and safety structure where a greater degree of flexibility in the salary arrangements is in our view essential. The Fleck Report on the Organisation for Control of Health and Safety in the United Kingdom Atomic Energy Authority[1] drew attention to the need for "permitting greater flexibility in the matter of salaries, particularly for the specialist medical staff . . . required to head the integrated health and safety organisations in the Industrial Group[2] works".

258. We accordingly looked into the pay and grading arrangements for radiological health and safety staff. In the medical field we think that the position is unsatisfactory. We regard it as important that the Authority should strike the right balance over the whole field because they are necessarily setting the standards which will govern the development of radiological health and safety as a distinct career avenue.

259. The salary of basic grade medical officers is on a scale which is rigidly tied to age up to the age of 40. More senior grades are paid fixed salaries. The arrangements for paying the medical hierarchy in the Authority could hardly be more rigid and are, in fact, more inflexible than those for any other professional or scientific staff. The reason is that the rates of pay are closely related to those of medical officers in government departments. We consider that this link is quite inappropriate. On the one hand the work and responsibilities of medical officers in the Authority are not comparable with those of medical officers in government departments; and on the other, it seems to us that their salary structure ought to be as flexible as that of the non-medical staff alongside whom they work in an integrated health and safety organisation. The salaries of individual officers need to be more closely related to their qualifications, experience, responsibilities and place in the organisation.

260. *We recommend:*

(a) *that the arrangements for pay and grading of medical staff in the Authority be brought into line, particularly in regard to flexibility, with those of the non-medical staff in the health and safety organisation;*

(b) *that the salary scale for medical officers should cease to be age-tied;*

(c) *that a new entry grade of assistant medical officer be introduced, and that promotion to the medical officer grade should on merit and without complementing restrictions.*

The interest of the work as a career

261. The intrinsic interest of the work, and the prestige and status accorded to it, are important. The Fleck Committee, in their Report on the Organisation

[1] Cmnd. 342 (H.M.S.O. 1958)—paragraph 94.

[2] Now divided into Production Group and Development and Engineering Group (see Chapter III, paragraph 94).

of certain parts of the United Kingdom Atomic Energy Authority, noted[1], for example, that "the Engineering and Research and Development Branches of the Industrial Group found it less difficult than the Operations Branch to attract sufficient recruits with an adequate technical background", because "people will be deterred from joining a branch which is wrongly regarded as not having a great deal of original thinking to do". For this reason opportunities for co-operating in research and for carrying out applied investigations should, as far as practicable, be given to health and safety staff with routine responsibilities.

262. Many factors can contribute to improving the standing of 'health and safety' as a career: developments in research in radiobiology and radiological physics in the universities; the success of postgraduate courses in the universities and colleges of advanced technology; the formation of a national radiological advisory service incorporating the existing Radiological Protection Service; and growing public awareness of the importance of radiological health and safety. The Authority gave valuable recognition by establishing a new Health and Safety Branch with increased Authority-wide responsibilities in July, 1959.

[1] Cmnd. 338 (H.M.S.O. 1957)—paragraph 41.

CHAPTER X

SUMMARY OF RECOMMENDATIONS

263. Our recommendations are summarised below, in the order in which they occur in the Report.

NATIONAL RADIOLOGICAL ADVISORY SERVICE

(1) We recommend the establishment of a national radiological advisory service as outlined in Chapter IV of this Report. (Chapter IV, paragraph 146).

NATIONAL TRAINING CENTRE

(2) We recommend that the Authority should not establish a national training centre (Chapter V, paragraph 155).

TRAINING OF SAFEGUARDS STAFF

(3) We recommend that the existing provision for formal training of safeguards staff be accepted as adequate. (Chapter VI, paragraph 160).

TRAINING OF RADIOLOGICAL PROTECTION STAFF

Graduates with the capacity ultimately to assume higher managerial responsibilities or to play a leading part in scientific development (category A)

(4) We consider that the existing and projected university postgraduate courses[1] will be adequate, when fully developed, to meet the estimated demand (including some small allowance for wastage). (Chapter VI, paragraph 173).

(5) We recommend that category A courses should be regarded for the time being as appropriately given in universities, without prejudice to possible later developments in colleges of advanced technology; that the courses should be on the lines of the outline syllabus at Appendix E; and that they should normally lead to an M.Sc. or Ph.D. degree. (Chapter VI, paragraph 174).

(6) We recommend that, in addition, other universities with research schools should be encouraged to accept each year a small number of students for postgraduate degrees in disciplines relevant to radiological health and safety. (Chapter VI, paragraph 175).

[1] Including the courses set up, or in process of being set up, as a result of our first interim report (see Chapter VI, paragraphs 162-172).

Staff having day-to-day managerial responsibilities or engaged in operational research (category B)

(7) We recommend that category B courses, lasting either three months (primarily for those already in employment), or one year (primarily for new graduates) on the lines suggested in Appendix G, be set up at colleges of advanced technology, priority being given to the three months' courses. (Chapter VI, paragraph 185).

(8) We recommend that consideration be given to setting up one of these category B courses at a college in Scotland, particularly in view of the existence of three major nuclear installations in Scotland. (Chapter VI, paragraph 186).

(9) We recommend that those students who successfully complete category B courses at colleges of advanced technology should be awarded appropriate college diplomas. (Chapter VI, paragraph 189).

Supporting staff without professional qualifications (category C)

(10) We recommend that courses on the lines of Appendix H should be provided either as full-time courses, or as day release courses, at technical colleges or at places of employment if no suitable technical college is available. (Chapter VI, paragraph 192).

(11) We recommend that the City and Guilds of London Institute should be invited to take immediate steps to set up an exploratory committee to consider the introduction of a City and Guilds course, at technical college level, in radiological protection. (Chapter VI, paragraph 195).

BACKGROUND TRAINING

(12) We recommend that further courses of background training for mixed groups of administrators, managers and professional workers should be provided by university extra-mural boards or colleges.[1] The demand is so great, that for some years any course which can be properly organised is likely to be fully taken up. (Chapter VII, paragraph 207).

The medical profession

(13) We recommend that:

(a) the curriculum for the Diploma in Public Health should include a course of instruction in radiological health and safety;

(b) the regulations governing the Diploma in Public Health, when next revised by the appropriate Special Committee of the General Medical Council, should make specific reference to instruction in radiological health and safety (Chapter VII, paragraph 213).

[1] See Chapter VII, paragraphs 202-204, for an account of the pilot course at Oxford, which resulted from our second interim report.

(14) We recommend that the medical schools consider the desirability of including in the basic medical curriculum some instruction in the use and hazards of ionising radiations; this instruction need not be elaborate, but should give a clear picture of the scientific principles involved and the significance of the effects. (Chapter VII, paragraph 215).

Books for the non-specialist reader

(15) We recommend that the Authority should explore the practicability of getting suitable books or pamphlets on radiological health and safety published for the non-specialist reader; they might be comparable in content to the framework for background training (Appendix I) or the Oxford conference (Appendix J). (Chapter VII, paragraph 221).

Films

(16) We recommend that films on radiological health and safety be made both for public information and as an adjunct to training; and that the Authority should, in consultation with interested government departments and with private and nationalised industry, work out a programme for the production of suitable films. (Chapter VII, paragraph 224).

Radio and television

(17) We recommend that the Authority and other bodies should, whenever possible, cooperate with radio and television organisations in the production of programmes designed to give the public a clearer idea of radiation hazards and the means by which they are controlled. (Chapter VII, paragraph 226).

THE ROLE OF THE AUTHORITY

(18) We recommend that the Authority should not provide general courses which can equally well be given by universities, colleges of advanced technology and technical colleges. (Chapter VIII, paragraph 240).

(19) We recommend that the Authority should continue to provide specialised courses and to arrange colloquia and conferences of a kind which cannot readily be provided in universities, colleges of advanced technology and other educational institutions. (Chapter VIII, paragraph 242).

RECRUITMENT AND RETENTION OF TRAINED STAFF

(20) We recommend that the normal D.S.I.R. machinery for the provision of grants for students at universities and colleges of advanced technology should be used, and that no special scheme of grants to

recruits is necessary or desirable for courses in radiological health and safety; we would however favour schemes made by employers to enable suitable established members of their staffs to attend such courses. (Chapter IX, paragraph 253).

(21) We recommend that special steps should be taken by the Authority and other employers to retain in the health and safety field successful students for the new courses we propose at category A and B level. (Chapter IX, paragraph 255).

Pay and grading of medical officers in the Authority

(22) We recommend:

(a) that the arrangements for pay and grading of medical staff in the Authority be brought into line, particularly in regard to flexibility, with those of the non-medical staff in the health and safety organisation;

(b) that the salary scale for medical officers should cease to be age-tied;

(c) that a new entry grade of assistant medical officer be introduced, and that promotion to the medical officer grade should be on merit and without complementing restrictions. (Chapter IX, paragraph 260).

We cannot close this report without expressing out gratitude to our secretaries and at rather greater length than is customary.

For the first four months the whole burden fell upon Dr. J. E. Johnston, whose wide knowledge of the subject and gift of precise and lucid explanation have been invaluable throughout our proceedings. From September to December, 1958, however, he was out of action on account of illness, and his work was divided between three colleagues, two from Harwell and one from the London Office, whose services we gratefully acknowledge.

In January, 1959, Mrs. Arnold, a newcomer to the London Office, was appointed assistant secretary since it had become obvious that additional help of high quality was urgently needed. The speed with which she picked up the threads and made herself mistress of the subject was admired by all of us.

Working harmoniously together, these two secretaries were responsible for

recording our discussions, getting additional information, and assembling the mass of evidence we had collected, and for preparing the first drafts of most of this report. The way they did it merits the highest commendation.

Finally, we wish also to acknowledge the services of their assistants. They have never once failed, in spite of the fact that they were constantly working against time, to have our papers punctually and accurately presented for our meetings.

DOUGLAS VEALE

E. ROCK CARLING	W. G. MARLEY
W. J. CARRON	W. V. MAYNEORD
J. A. T. DAWSON	R. A. THOMPSON
W. M. LARKE	I. WILLIAMS
A. S. McLEAN	B. W. WINDEYER

Secretaries:

J. E. JOHNSTON

LORNA ARNOLD

22nd February, 1960.

APPENDIX A

SOURCES OF EVIDENCE

1 The following government departments, professional bodies, university appointments boards and other organisations gave written information to the Committee:

(1) *Government departments*

Admiralty
Air Ministry
Colonial Office
Commonwealth Relations Office
Department of Scientific and Industrial Research
Foreign Office
Government Chemist's Department
Home Office
H.M. Customs and Excise
H.M. Treasury
Ministry of Agriculture, Fisheries and Food
Ministry of Aviation[1]
Ministry of Defence
Ministry of Education
Ministry of Health
Ministry of Housing and Local Government
Ministry of Labour
Ministry of Power
Ministry of Transport[1]
Ministry of Works
Office of the Minister for Science, Atomic Energy Division[2]
Post Office
Scottish Office
University Grants Committee
War Office

Northern Ireland

Ministry of Agriculture
Ministry of Commerce
Ministry of Education
Ministry of Health and Local Government
Ministry of Home Affairs
Ministry of Labour and National Insurance

(2) *Nationalised industries and government organisations*

Central Electricity Generating Board
Radiological Protection Service
U.K. Atomic Energy Authority

[1] Initially evidence relevant to these two departments was obtained from the former Ministry of Transport and Civil Aviaition.

[2] Initially evidence was obtained from the former Atomic Energy office.

(3) *Professional bodies*

Faculty of Radiologists
General Medical Council
Society of Medical Officers of Health
Society of Radiographers

(4) *University appointments boards*

Aberdeen
Belfast
Birmingham
Bristol
Cambridge
Durham
Edinburgh
Exeter
Glasgow
Hull
Leeds
Leicester
Liverpool
London
Manchester
Nottingham
Oxford
Reading
St. Andrews
Sheffield

II The following bodies gave information orally to the Committee through the representatives named:

Government departments and official bodies	
City and Guilds of London Institute	Major General C. Lloyd, C.B., C.B.E., T.D. D. E. Wheatley
Colonial Office	E. G. G. Hanrott, M.B.E.
Commonwealth Relations Office	F. S. Miles
Department of Scientific and Industrial Research	C. Jolliffe E. Rudd
Foreign Office	A. J. D. Stirling
Medical Research Council	B. S. Lush
Ministry of Agriculture, Fisheries and Food	J. G. Carnochan D. R. Dow
Ministry of Education	A. Thompson
Ministry of Health	E. T. Prideaux, O.B.E. L. H. Brandes D. Thompson
Ministry of Housing and Local Government	T. D. Wickenden, C.I.E. F. J. Ward

Ministry of Labour and National Service[1]	H. F. Rossetti H. E. Chester F. Pickford B. W. A. Crutchlow
Ministry of Power	H. J. Gummer
Ministry of Transport and Civil Aviation[2]	J. E. Hampson
Scottish Office	G. F. Belfourd
University Grants Committee	E. R. Copleston, C.B.
Professional bodies	
Hospital Physicists' Association	F. T. Farmer R. F. Farr
Society of Medical Officers of Health	Sir Selwyn Selwyn-Clarke, K.B.E., C.M.G., M.C. H. D. Chalke, O.B.E., T D F. T. Madge Katharine Williams
Universities	
University of Oxford: Delegacy for Extra-Mural Studies	F. W. Jessup

III The following persons gave information orally or in writing to the Committee in their personal capacities:

R. S. Aitken, Vice-Chancellor, University of Birmingham.

Sir Edward Appleton, G.B.E., K.C.B., F.R.S., Principal and Vice-Chancellor, University of Edinburgh.

Professor C. C. Butler, Professor of Physics, Imperial College of Science and Technology.

Sir David Campbell, M.C., Regius Professor of Materia Medica and Therapeutics, University of Aberdeen.

J. Dainty, Reader in Biophysics, University of Edinburgh.

Professor P. I. Dee, C.B.E., F.R.S., Professor of Natural Philosophy, University of Glasgow.

L. R. B. Elton, Head of Department of Physics, Battersea College of Technology.

Professor N. Feather, F.R.S. Professor of Natural Philosophy, University of Edinburgh.

C. E. Gurr, Chief Education Officer for Middlesex.

C. F. Harris, Vice-Chancellor, University of London.

Sir Hector Hetherington, K.B.E., Principal and Vice-Chancellor, University of Glasgow.

Sir Harold Himsworth, K.C.B., F.R.S., Secretary of the Medical Research Council.

B. E. Lawrence, C.B.E., Chief Education Officer for Essex.

Sir Patrick Linstead, C.B.E., F.R.S., Rector of the Imperial College of Science and Technology.

Sir Douglas Logan, Principal of the University of London.

[1] Now the Ministry of Labour.

[2] Now Ministry of Transport and Ministry of Aviation.

J. F. Loutit, C.B.E., Director, Radiobiological Research Unit, Medical Research Council.

J. W. Lucas, Senior Lecturer in Radiochemistry, Liverpool College of Technology.

Professor J. S. Mitchell, C.B.E., F.R.S., Regius Professor of Physic, University of Cambridge.

Professor P. B. Moon, F.R.S., Poynting Professor of Physics, University of Birmingham.

Sir Charles Morris, Vice-Chancellor, University of Leeds.

D. F. Ellison Nash, Dean of the Medical College of St. Bartholomew's Hospital.

J. H. P. Oxspring, M.B.E., Director of Education for Staffordshire.

Professor C. F. Powell, F.R.S., Melville Wills Professor of Physics, University of Bristol.

Professor M. H. L. Pryce, F.R.S., Henry Overton Wills Professor of Physics, University of Bristol.

Professor J. E. Roberts, Joel Professor of Physics as applied to Medicine, The Middlesex Hospital Medical School.

Professor J. Rotblat, Professor of Physics, Medical College of St. Bartholomew's Hospital.

K. S. W. Sing, Head of Department of Chemistry and Biology, Liverpool College of Technology.

Professor F. W. Spiers, Professor of Medical Physics, University of Leeds.

Professor J. R. Squire, Leith Professor of Experimental Pathology, University of Birmingham.

P. F. R. Venables, Principal, City of Birmingham College of Advanced Technology.

IV Visits were made by members of the Committee, or the Secretaries, to the following:

Agricultural Research Council, Radiobiological Laboratory, Grove, Wantage.
Atomic Power Constructions Ltd.
City of Birmingham College of Advanced Technology,
English Electric—Babcock and Wilcox—Taylor Woodrow Atomic Power Group.
Ford Motor Company, Dagenbam.
Gamma-Rays Ltd., Smethwick.
G. E. C.—Simon Carves Group of Companies.
Institute of Cancer Research, Royal Cancer Hospital.
Metropolitan Vickers Electrical Co. Ltd., Trafford Park.
" " " " " Wythenshawe.

New York University, Postgraduate Medical School.
Northern Ireland: Ministry of Agriculture.
Ministry of Commerce.
Ministry of Education.
Ministry of Health and Local Government.
Ministry of Home Affairs.
Ministry of Labour and National Insurance.
Nuclear Power Group.

Radiological Protection Service, Sutton, Surrey.
Royal Technical College, Salford

Royal Navy: Atomic Defence and Damage Control School, Portsmouth.
Stewarts and Lloyds Ltd., Corby.
„ „ „ „ Halesowen.
The Churchill Hospital, Oxford.
The General Hospital, Birmingham.
The Middlesex Hospital, London.
The Queen Elizabeth Hospital, Birmingham.
The Radcliffe Infirmary, Oxford.
The Royal Sussex County Hospital, Brighton.
Unit Superheater and Pipe Co. Ltd., Swansea.
United Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Harwell.
„ „ „ „ „ Capenhurst Works.
„ „ „ „ „ Health and Safety Branch, Risley.
„ „ „ „ „ Windscale and Calder Hall Works.
United States Atomic Energy Commission, Division of Biology and Medicine.
University of Birmingham.

APPENDIX B

LEGISLATION SPECIFICALLY RELATED TO RADIOLOGICAL HEALTH AND SAFETY

(This Appendix does not deal with general legislation or obligations under Common Law)

1. *The Radioactive Substances Act*, 1948

Section 5 of the Act (subsections (1)-(7)) deals with radiological health and safety measures, and empowers the Ministers concerned to make such regulations[1] as may appear necessary after consultation with the Radioactive Substances Advisory Committee established under the Act (Section 6). Section 5 of the Act provides as follows:

Safety regulations for occupations involving radioactive substances and irradiating apparatus.

"5.-(1) The appropriate Minister may, as respects any class or description of premises or places specified in the regulations, being premises or places in which radioactive substances are manufactured, produced, treated, stored or used or irradiating apparatus is used, make such provision by regulations as appears to the Minister to be necessary—

(a) to prevent injury being caused by ionising radiations to the health of persons employed at those premises or places or other persons; or

(b) to secure that any radioactive waste products resulting from such manufacture, production, treatment, storage or use as aforesaid are disposed of safely;

and the regulations may, in particular and without prejudice to the generality of this subsection, provide for imposing requirements as to the erection or structural alteration of buildings or the carrying out of works.

(2) The appropriate Minister may, as respects the transport of any radioactive substances, make such regulations as appear to him to be necessary to prevent injury being caused by such transport to the health of persons engaged therein and other persons.

(3) Regulations made under this section may provide for imposing requirements, prohibitions and restrictions on employers, employed persons and other persons.

(4) Any person who contravenes or fails to comply with any regulation made under this section or any requirement, prohibition or restriction imposed under any such regulation shall be guilty of an offence.

(5) Before making any regulations under this section, the appropriate Minister shall consult with the Advisory Committee established under this Act.

[1] No regulations have yet been made.

(6) In this section the expression "the appropriate Minister" means such Minister, or such Ministers acting jointly, as may be designated by Order in Council, and different Ministers may be designated, for the purposes of subsection (1) of this section, for different classes or descriptions of premises or places and, for the purposes of subsection (2) of this section, for different forms of transport or for the transport of different classes or descriptions of substances.

(7) This section shall be without prejudice to the provisions of the Factories Act, 1937, as amended by any subsequent enactment."

For purposes of carrying out these provisions, the Ministers concerned may appoint persons with rights of entry and inspection. (Section 7 of the Act).

2. *Atomic Energy Authority Act*, 1954

The Atomic Energy Authority was set up by the Atomic Energy Authority Act, 1954. Subsections (3) and (4) of Section 5 of the Act provide as follows:

"5.-(3) It shall be the duty of the Authority to secure that no ionising radiations from anything on any premises occupied by them, or from any waste discharged (in whatever form) on or from any premises occupied by them, cause any hurt to any person or any damage to any property, whether he or it is on any such premises or elsewhere.

(4) The following provisions shall, for the period of seven years beginning with the day of the passing of this Act, have effect as respects waste discharged (in whatever form) on or from any premises occupied by the Authority:

(a) no radioactive waste shall be discharged otherwise than in accordance with authorisations to be given by the Minister of Housing and Local Government and the Minister of Agriculture and Fisheries, after consultation, in each case, with such local authorities, river boards, local fisheries committees or other public or local authorities as appear to the Minister in question to be proper to be consulted by him;

(b) the said authorisations may be given subject to compliance with such conditions and requirements as the Minister in question thinks fit;

(c) any person authorised in that behalf by either of the said Ministers may enter and inspect such parts of any premises occupied by the Authority and take or cause to be taken such samples of waste which is being discharged or awaiting discharge thereon or therefrom as may appear necessary for ascertaining whether any breach of any such condition or requirement is or is likely to be committed;

(d) for the purposes of any statutory provision conferring or imposing powers or duties on any local authority, river board, local fisheries committee or other public or local authority (and, in particular, for the purposes of the Public Health Acts, 1936 and 1937, the Rivers (Prevention of Pollution) Act, 1951, the Salmon and Fresh Water Fisheries Act, 1923, the Sea Fisheries Regulation Act, 1888, and any corresponding enactment in force in Scotland) all waste discharged on or from any premises occupied by the Authority shall be conclusively presumed not to be radioactive to any significant extent:

Provided that Her Majesty may by Order in Council (which shall be subject to annulment in pursuance of a resolution of either House of Parliament) abridge or from time to time extend the said period of seven years, and the preceding provisions of this subsection shall have effect accordingly.

For the avoidance of doubt, it is hereby declared that the restrictions imposed by this subsection on the Authority are in addition to and not in derogation of their duty under the last preceding subsection, and that the presumption required to be made by paragraph (d) of this subsection operates only for the particular purposes mentioned in that paragraph.

In the application of this subsection to Scotland, references to the Secretary of State shall be substituted for references to the Minister of Housing and Local Government and the Minister of Agriculture and Fisheries."

3. *Nuclear Installations (Licensing and Insurance) Act*, 1959

The whole of this Act is relevant, but particularly subsection (5) of Section 1, which reads as follows:

"1 -(5) Subsection (4) of section five of the Atomic Energy Authority Act, 1954 (which makes temporary provision with respect to the discharge of waste on or from premises occupied by the Authority) shall apply to any licensed site as it applies to such premises as aforesaid; and accordingly references in the penultimate paragraph of the said subsection (4) to the Authority and to their duty under subsection (3) of the said section five shall be construed as including respectively references to a licensee and to his duty under subsection (1) of section four of this Act"

4. *Radioactive Substances Bill*

The whole of this Bill (the provisions of which are briefly outlined in Chapter III, paragraphs 30 and 79) is relevant.

5. *The Factories (Luminising) Special Regulations*, 1947

These Regulations (dated 7th May, 1947), made by the Minister of Labour and National Service under Section 60 of the Factories Act, 1937, cover the use of radioactive luminising materials in factories. The Regulations are relevant throughout.

APPENDIX C

SAFEGUARDS STAFF REQUIREMENTS AND TRAINING

1. The problems of achieving safety or minimising the possibility of hazard in the large-scale development and application of atomic energy falls into two broad subdivisions which are consistent with the general pattern of control now being developed by Ministries. One aspect, the provision for the regulation of nuclear installations, is covered by the Nuclear Installations (Licensing and Insurance) Act, 1959. Its purpose is "to control, in the interests of safety, the building and operation of nuclear reactors and other fixed nuclear installations". This Act is concerned with ensuring that nuclear installations are properly constructed and managed so as to minimise the potential hazard. The second aspect is concerned with the people who operate these installations: regulatory powers are being developed under the Minister of Labour to ensure that these people are not exposed to excessive levels of radiation.

2. The first of these two aspects falls under the heading of "safeguards" and the second under "radiological protection" and, in any large organisation, suitably trained staff will be required to administer these functions. Staff will also be required by Ministers to enable them to exercise their responsibilities under these two headings. This paper is concerned with the safeguards function and will explore in some detail the work required under this heading.

3. Major atomic energy installations are created by a design group. Their creation will be based on development work which may in some cases include earlier small-scale prototypes. The design group will take into account the information available from these earlier developments and they will also consider whether the engineering techniques required are well based and adequately proven. Economic factors will tend to force the designer to attempt construction of advanced types of installation at an early date and at minimum cost. He will have to weigh these factors against the available experience and the risks involved in attempting such a programme.

4. The operator will eventually take over, commission and operate the plant. He, too, will be under pressure to operate at a high power level at an early date, and he will have to compromise between tbe slow timescale attendant on a soundly based research programme and the valuable experience that results from operation at full power.

5. The Authority have set up a Health and Safety Branch which is independent of the design and operating groups, with the object of introducing a fresh and unbiased viewpoint in the judgement applied to those various factors in relation to the overall safety of the installation. At the present time, proposals for the construction or operation by the Authority of any major plant are submitted to this Branch for scrutiny, in order to obtain their comments on safety aspects before the project is approved. At an advanced stage of construction, a complete hazard assessment for the plant is prepared under the direction of the operator and submitted again for scrutiny by the Health and Safety Branch. This may lead to an approval to operate, subject to certain conditions. During the operation of the plant, the fulfilment of these conditions will be a matter for inspection by the Branch. On a national level the Ministry of Power will examine proposals for the construction and operation of atomic energy installations other than by the Authority and will license these installations, subject to such conditions as they may wish to impose. The Ministry will also be responsible for the subsequent inspection of the installations.

6. The procedure described above has much in common with the practices which have grown up in the United States. Under the United States law, all operators must seek a licence from the Atomic Energy Commission, first to construct and secondly to operate.

7. The act of carrying out a critical scrutiny of a large and complex plant requires a wide range of skills in the applied sciences, such as heavy civil and mechanical engineering construction; light engineering as applied to control machinery, etc.; electrical and electronic engineering; both reactor and applied physics, particularly hydrodynamics; chemistry and metallurgy as applied to the basic properties of new materials developed; and the behaviour of materials under irradiation. The team should include mathematicians who will require computing facilities. As there can be no absolute standard in safety, considerable skill is required in applying the judgement of the experts in their respective fields.

8. Whilst for some time the Authority may be the only organisation which can carry a large and complex staff for this type of technical safety assessment, it is clear that other staff will be required by the various Ministers having responsibility in reactor safety, in particular the Minister of Power and the Minister of Transport. In addition any major designer or operator will need to have sound expert advice and will require to train staff for this purpose. The major operator for some time will be the Central Electricity Generating Board. Other operators will include the North of Scotland Hydro Electric Board, the South of Scotland Electricity Board and the Electricity Board of Northern Ireland; the Admiralty; the consortia of firms interested in the design of large-scale plant; and to these others may be added with a particular bias towards marine applications.

Staff requirements

9. The Authority currently have a (professional) safeguards staff of 75 to 80 in the central Authority Health and Safety Branch and expect to increase this number to 97. In addition, 12 to 20 people with specific responsibility in this field are likely to be required by the design and operating groups within the next few years. The Authority can only guess the requirements of all the other bodies mentioned. They are likely to lead to a growing requirement of not less than 50 over the next 5 years.

Training

10. In order to exercise an informed and critical judgement on proposals for design, construction or operation, it is essential that many of the safety staff themselves should have had experience in these matters. It is particularly important that judgement on operation and reactor physics should be based on prolonged experience. Broadly, all the skills applied in the safeguards section can be found applied elsewhere, and the problem in choosing staff is one of obtaining a reasonable mixture of technical competence and sound critical judgement.

11. People chosen from other industries would normally be given some formal training within the Authority during their first six months. This training serves two functions; in the first place, it is an introduction to the Authority and in the second place, an introduction to the special techniques of physics, mathematics, engineering, etc. as applied to Authority work. After formal training, the new entrant develops his training "on the job" as part of a composite team engaged in the work of reactor assessment. In taking part in the work of a team, the newcomer is given many opportunities for broadening his experience, either in the design office or through his many visits to the operating sites.

Formal training facilities which have been used

12. OAKRIDGE NATIONAL LABORATORY, U.S.A.

Reactor hazards evaluation course—12 months duration.

HARWELL REACTOR SCHOOL COURSES

(i) "Instrumentation and Control of Reactors" course for postgraduate or equivalent level—2 weeks course—occurs about twice a year.

(ii) Harwell Standard Reactor School Course—for postgraduate or equivalent level—16 weeks course—occurs twice a year.

(iii) Senior Technical Executive Course—2 weeks course—occurs twice a year.

HARWELL ISOTOPE SCHOOL COURSE

General Isotope Course—approximately 1 month course—five courses a year.

BRADFORD INSTITUTE OF TECHNOLOGY

College part of the Harwell Reactor School Standard Course—occurs twice a year —6 weeks course—for postgraduate or equivalent level.

ROYAL TECHNICAL COLLEGE, SALFORD

College part of the Harwell Reactor School Standard Course—occurs twice a year —6 weeks course—for postgraduate or equivalent level.

MANCHESTER UNIVERSITY

Postgraduate Nuclear Engineering Course—occurs annually—6 weeks course.

CALDER OPERATION SCHOOL

(Theoretical part of the courses held at Whitehaven College of Further Education) "Theory and Practice of Reactor Operation"—for postgraduate or equivalent level, primarily for the electricity generating boards and consortia staff—6 to 8 weeks course—occurs five times a year.

13. In addition, Health and Safety Branch staff attend symposia, held at Authority establishments, on a variety of subjects, e.g. heat transfer, fast reactor, moderator materials, non-metallic fuel elements. There are also periodic training visits to the Authority factories.

F. R. FARMER
Head of Safeguards Division
Authority Health and Safety Branch

APPENDIX D

COURSES IN RADIOLOGICAL PROTECTION

Excluding courses (a) conducted by employers for their own staff and (b) courses in which radiological protection is only an element of the training

I. Courses at Universities Leading to Higher Degrees

University of Birmingham (Faculties of Science and Medicine)

(a) Course of lectures and practical work in radiobiology and radiological physics, leading to the degree of M.Sc. by examination. Duration one year full-time. Candidates require a good honours degree in an appropriate physical, biological or medical science. Started in 1959. Fuller details are given in Appendix F.

(b) Students suitably qualified may proceed to the degree of Ph.D. by research after a minimum of two further years.

University of Cambridge (Department of Radiotherapeutics)

One or two research students have been accepted for training in the field of radiological physics and radiobiology, leading to the degree of Ph.D., subject to the approval of the Regius Professor of Physic and the Board of Postgraduate Studies.

University of Edinburgh (Department of Biophysics) (planned to start in October, 1960)

(a) A one-year full-time course of lectures and laboratory work open to candidates with good honours degrees in science (or graduates in medicine) leading to a Diploma in Biophysics by a written and oral examination. The curriculum includes biophysics, biology, radiation biology, physiology and biochemistry.

(b) Students who have obtained this Diploma in Biophysics may register for a two-year course for the degree of Ph.D. The course for this degree will include attending further lectures and carrying out research in radiobiology and radiological physics.

University of Leeds (Department of Medical Physics)

Two or three students can be accepted for research in radiobiology and radiological physics leading to the degree of Ph.D.

University of London

(i) *Institute of Cancer Research, Royal Cancer Hospital (Physics Department) in collaboration with University College (Departments of Biology and Physiology)*

   (a) A two-year full-time course of lectures and practical work, open to students with good honours degrees in either physical or biological subjects, leading to the degree of M.Sc. in biophysics. Students have to present a dissertation on research undertaken and sit a written examina-

tion. General training in biology and physiology is given in the first year and more specialised lectures in radiobiology and radiological physics during the second.

(b) A three-year full-time course, open to students with good honours degrees in either physical or biological subjects, leading to the degree of Ph.D. The emphasis is on research in the field of radiophysiology. For the first year formal training in botany, zoology and physiology is given at University College, followed by a written examination; during the second year there are courses of lectures on a variety of related subjects; the third year is devoted solely to a research project which has been started during the first year. At the end of the third year a thesis is presented.

(ii) *The Middlesex Hospital Medical School (Department of Physics as applied to Medicine) jointly with St. Bartholomew's Hospital Medical College (Physics Department).* A two-year course of lectures and practical work, open to graduates in physics or allied subjects fulfilling the entry requirements for the M.Sc. of the Faculty of Science, University of London, leading to the degree of M.Sc. in Radiation Physics. The course is mainly academic in content but includes the applications of ionising radiations and particles in medicine and biology. There are two lectures each week and in addition to practical work students assist in the research work of the department concerned.

II. Shorter Courses at Universities, Colleges of Advanced Technology and Technical Colleges

Aberdeen: *University of Aberdeen.* The initial plans are that there should be in the autumn of 1960 a "Basic Course on Radiobiology" consisting of about nineteen lectures and ten laboratory periods spread over about ten weeks. (It is intended that at a later stage instruction in radiobiology be included in courses for the degree of B.Sc. subsequent to the M.B., Ch.B.; and that there be courses in radiobiology leading to a Diploma in Radiobiology or the degree of M.Sc.)

Letchworth: *North Herts Technical College (Department of Science and Electrical Engineering)* "Radiological Protection". A series of ten weekly evening lectures (January-March 1960).

Liverpool: *Liverpool College of Technology.* "Radiation Safety and Health Physics". A two-week full-time course (consisting of lectures, visits to local works and institutions, demonstrations and practical work) which provides an introduction to the problems of radiological protection suitable for works safety and medical officers, medical officers of health, public health inspectors and factory inspectors. Courses are mounted approximately once every two months.

London: *Battersea College of Technology (Department of Physics).* "Radiological Protection" (session 1959-60). A course of twenty weekly evening lectures, and a course of five weekly laboratory periods. Students attending the complete course are eligible to sit the examination for the College Certificate in Radiological Protection.

Sir John Cass Technical College. "Radioactivity and its Hazards in Biology and Medicine". A course of eleven weekly evening lectures, from January to March each year, designed to meet the needs of those who are starting work with radioactive substances or who are interested in the problems of radiation protection.

University of London

Imperial College of Science and Technology. (Nuclear Technology Laboratories). A two-week summer school in "Health Physics (Radiation Protection)" starting on 4th July, 1960. For candidates with degrees in science or medicine who are university radiation protection officers, industrial safety officers concerned with radiation and radioactive hazards, medical officers of bealth, factory inspectors etc. The course consists of lectures and practical work.

The Middlesex Hospital Medical School. (Department of Physics as applied to Medicine). A six-week course of lectures, demonstrations and practical work in "Radiation Hazards and Safety" starting on 25tb April, 1960. An introduction to the subject suitable for medical, engineering, chemical and other professional workers wbose duties require an overall appreciation of the problems involved in maintaining radiological safety in the utilisation of radiations and radioactivity in industry and medicine.

III. COURSES AT OTHER CENTRES

Admiralty

Royal Naval Medical College, Alverstoke. A five-day course providing the basic knowledge that service and civilian medical officers and others concerned need in order to understand tbe short and long term effects of an atomic explosion and the dangers from other kinds of radiological warfare. About six courses are held each year. These courses are attended mainly by Royal Naval Volunteer Reserve personnel; a number of places are reserved for officers from the other Services, from government departments etc. Furtber information may be obtained from the Medical Officer in Charge, Royal Naval Medical School, Alverstoke, Hants.

United Kingdom Atomic Energy Authority

Harwell, Isotope School. "Radiological Protection". A five-day course of lectures, visits, demonstrations and practical work at graduate level. Normally there are two courses each year. Tbe aim of the course is to give practical advice on radiological protection of direct use to people actually engaged in handling radioisotopes.

Harwell, Reactor School. "Principles of Radiation Protection". An eleven-week course of about 100 lectures, visits, demonstrations and practical work. The course is designed for students at graduate level who are taking up full-time health and safety duties, and covers at an advanced level the principles, rather than particular techniques, of radiobiology and radiological physics.

(The second course starts on 20th April, 1960).

Windscale. "Health Physics". A two-week course consisting of lectures, study periods, practical work and visits to plant to see health physics control in operation. The course gives a general background training in health physics suitable for the staff of nuclear engineering consortia, electricity generating boards and others concerned with the construction and operation of nuclear power stations. About six courses are held each year.

Glasgow. Western Regional Hospital Board. "Radiation and Public Health". Three-day courses of lectures, discussions and demonstrations for Scottish and Irish medical officers of health on the health hazards associated with the peaceful uses of atomic energy. To date three courses have been held. One-day refresher and other courses are also beld.

Note: Since the report was completed information on the following projected courses has been received from the Ministry of Education:

Royal Technical College, Salford

(a) A full-time course on radiological health and safety of 6-9 months for graduates in science or engineering (or equivalent) leading to the Certificate of the Royal Technical College. The first section will cover the basic science and the second half its application to radiation hazards. Planned to start in September, 1960.

(b) A full-time postgraduate course of two or three years leading to the Fellowship of the Royal Technical College (at M.Sc. or Ph.D. level). Planned to start in September, 1960.

Liverpool College of Technology

A full-time course of six months on radiation safety and health physics offered in two parts which may be taken separately. Part 1 lasts for about twelve weeks and contains lectures and practical work. Part 2 consists of a selected project of original work lasting for about fourteen weeks. Satisfactory completion of the whole course leads to the Diploma of Liverpool College of Technology. A College Certificate may be awarded for success in the individual parts.

APPENDIX E

CATEGORY A
PROPOSED POSTGRADUATE COURSES OF STUDY

1. The Committee have attempted to devise suitable courses of postgraduate study, related directly to radiological health and safety, for students of the highest calibre who have already graduated in science or medicine.

2. It is suggested that such candidates be required to follow a three-year full-time course of training such as those at present leading to a Ph.D. degree in some relevant subject which might be designated as biophysics. This training (see below) should include instruction in fundamental biological as well as physical sciences and should be designed so as to cover a very wide area. In addition to attendance at lecture courses such candidates would be required to carry out a research project in a relevant branch of science. They would be expected to write a thesis on their research and also to submit to such other oral or written examinations as might be desirable.

3. There will also be a need for the training of considerable numbers to a less advanced level, for which courses of full-time instruction over a period of one or two years would be desirable, this instruction being such as would normally lead to the degree of M.Sc. Such candidates would be required to write a dissertation which might contain little original work but consist largely of a critical examination of some relevant topic. Details of the course would have to be designed by the particular universities concerned in the teaching, and the outline below is merely a guide.

4. Careful consideration should be given to the possibilities of students being exempted from such particular portions of the courses as may have been included in their previous training. It must not however be forgotten that frequently a candidate who has even a higher degree in a particular subject such as physics may not necessarily have dealt in detail with radiation physics previously.

5. As it is probable that many of the candidates will have degrees in physics before starting these courses but little or no training in biological subjects, the first year should largely be devoted to biological aspects of the problems.

OUTLINE SYLLABUS

1. First year:
   (a) Start of research project.
   (b) Courses of instruction in:
      Zoology—2 lectures and 2 practical classes a week throughout 2 terms of the academic year.
      Botany—1 lecture and 1 practical class a week throughout 2 terms of the academic year.
      Human physiology—2 lectures and 2 practical classes a week throughout the academic year.
   (c) Courses in radiation physics, particularly such aspects as the physical interaction of ionising radiation with tissues, absolute measurement of radiation, dosimetry. In all 15 lectures.

2. Second year:

(a) Continuation of research project.

(b) Courses of instruction in such selected subjects as:

Radiobiology—2 lectures a week and 2 practical classes throughout 2 terms of the year	35 lectures.
Environmental radioactivity and human metabolism	10 lectures.
Radiochemistry	10 lectures.
Meteorology including such subjects as diffusion, aerosols, adsorption	5 lectures.
Reactor design and construction	5 lectures.
Medical and industrial applications of radioactive isotopes	5 lectures.
Maximum permissible levels, relevant legislation, codes of practice	5 lectures.
	75 lectures.

3. Third year:

Continuation of research project plus lectures on special relevant topics. These might include such subjects as statistics and the design of biological experiments. During this year it is important that visits be paid to atomic energy research establishments and acquaintance be made with practical problems in the field.

APPENDIX F

UNIVERSITY OF BIRMINGAM

FACULTIES OF SCIENCE AND MEDICINE

POSTGRADUATE COURSE AND TRAINING IN RADIOBIOLOGY

A course of lectures and practical work in radiobiology will be provided jointly by the Faculties of Science and Medicine during the session 1959-60. This will normally lead to an M.Sc. degree by examination at the end of twelve months and students suitably qualified will then be able to proceed to a Ph.D. by research after a minimum of two further years. The award of the degrees is subject to the general regulations of the University.

Intake

Candidates will be required to have a good honours degree in an appropriate physical, biological or medical science.

Aim

To provide a course of study at postgraduate level designed to produce scientists capable of appreciating and dealing with radiobiological problems.

Fee

The fee for the course is £95 0s. 0d.

Scope

Appropriate introductory instruction will be given in biology, atomic and nuclear physics and/or chemistry to assimilate students of various disciplines.

The main body of instruction will consist of courses in:

(i) *Physics* (to be given by the Department of Physics).

Radioactivity and nuclear radiations, including physical and chemical preparation of radioactive substances, dosimetry and radiation shielding. Interactions of radiations with matter—absorption, scattering, cross-sections. Gamma-ray spectrometry.

(ii) *Chemistry* (by the Department of Chemistry).

The chemistry of macromolecular substances. Tracers, carriers. Radiation chemistry. Fission product elements. Chemical effects of radiation on cell materials.

(iii) *Biology* (by the Departments of Botany and Zoology).

A brief description of the classification of animals and plants, their anatomy and structure. Selected relevant aspects of animal and plant physiology and ecology. Metabolism and food chains.

(iv) *Genetics* (by the Department of Genetics and Microbiology).

Effects of radiation on the hereditary materials, nuclear and cytoplasmic; the consequence of these effects for cells, tissues, individuals and populations.

(v) *Medical biochemistry, experimental pathology and radiotherapy*

(by the Departments of Medical Biochemistry and Experimental Pathology, with the co-operation of University Clinical Lecturers in Radiotherapy).

(a) Studies in human metabolism, including balance studies; the dynamic state of body constituents, intermediary metabolism and enzymology, intracellular anatomy, experimental use of radioisotopes.

(b) Acute and chronic effects of radiation, radiosensitivity of tissues including

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PROGRAMME

L—Lectures, T—Tutorials, P—Practical, D—Demonstrations

Some of the courses shown in italics may be omitted by those with appropriate qualifications

Term	Category		
	Biology (hours)	Physics (hours)	Chemistry (hours)
Vacation and Autumn	*Zoology* 40 D Po *Botany* 10 L 10 P *Genetics* 5 D *Statistical principles* 10 L	*Physics (introductory)* 15 L 20 P *Radiation (introductory)* 5 L 15 P	*Organic and elementary radiation chemistry* 40 D P
		Nuclear radiations 15 L 60 P	Radiation and tracer chemistry 30 L P
Spring	Animal physiology and ecology 70 D P Med. biochem., exp. pathology and radiation effects in man 150 D T Radiation genetics 20 L 40 P	Nuclear radiations 60 P	Radiation and tracer chemistry 10 L 30 P
Summer	Plant physiology and ecology 10 L 20 P Med. biochemistry and exp. pathology 100 D T	Nuclear radiations 30 P Radiation shielding 5 L Codes of practice—present status of hazards from nuclear radiation 5 L	
Vacation	Extra-mural work.	Meteorology—5 lectures.	Studies in preparation for M.Sc.

Note: This syllabus refers specifically to the first (1959-60) course. The syllabus is to be reviewed in the light of the first year's experience, and it would not be unreasonable to expect some changes in such a complex and advanced programme of teaching.

modifying factors; relative biological efficiency; dosimetry in heterogeneous media; therapeutic uses of radiation and radioactive isotopes.

(vi) *Radiation protection* (by the Department of Physics and visiting lecturers).

Applications of basic knowledge; safety precautions in practical uses of radiation; codes of practice: present status of hazards from nuclear radiation. Basis of permissible radiation levels. Radioactive wastes: public health requirements.

Notes: (1) Emphasis will be laid on laboratory studies, with opportunities for visiting atomic energy establishments, industrial installations and medical centres with diagnostic and therapeutic facilities.

(2) The above syllabus is an outline and may be revised in some details.

APPENDIX G

CATEGORY B

PROPOSED FULL-TIME COURSES OF STUDY AT GRADUATE LEVEL

1. Scientists who have managerial responsibilities in the field of radiological health and safety, or who are carrying out research in the subject, require assistant staff of graduate level (or equivalent qualifications). Such men would normally constitute the assistant staff in such places as the larger establishments of the Atomic Energy Authority, but elsewhere might themselves have full responsibility for health and safety. They would be employed full-time on health and safety duties.

2. In addition to having basic training to graduate or near graduate level, they must be well trained in radiological health and safety, since they would fill posts with a fair measure of responsibility, would undertake a certain amount of development work and would supervise the day to day operations of supporting staff.

3. Whilst the suggested course of full-time training for this category given below includes some instruction in the fundamentals of radiobiology and radiological physics, it also deals with technological aspects of the problem.

4. As candidates for the course will already hold qualifications such as degrees, Diplomas in Technology, Higher National Diplomas or Certificates in various scientific or engineering subjects, or equivalent qualifications, there will be a considerable difference in their knowledge of fundamental science or mathematics. The syllabus given below has been planned to begin with first principles since few if any academic courses cover all the necessary subjects. *In addition it will frequently be necessary for some candidates to attend preliminary courses in selected topics in physics, chemistry or mathematics before embarking on the course.* The scope and standard of teaching required for such preliminary courses could be provided without difficulty by colleges of advanced technology.

5. It is proposed that courses should be full time and last for either three months or one year.

6. *The three-month course would be primarily for adequately qualified people, who may have had in addition experience in a field of science or technology. They would have considerable background knowledge and practical experience of how to tackle the problems met in their place of employment.* People with this background who are chosen for full-time health and safety duties require training in those parts of physics, chemistry and biology which are directly relevant to radiological health and safety work, and practical experience with the essential measuring techniques and instruments used. Visits to selected installations and plant to see existing practices will also be necessary. It is important for these people to have a sound knowledge of methods of dealing with practical problems as well as detailed academic knowledge of the fundamentals of the subject.

7. For practical reasons employers will wish staff they have designated for this work to be trained in the minimum possible time.

8. The one-year course would give a longer period in which to absorb the basic parts of physics, chemistry and biology relevant to health and safety work. This longer course would be for (a) those who have just qualified at the level described in paragraph 4 and have not had any additional experience in industry or elsewhere and (b) similarly qualified people from industry who require a longer training than the intensive three-month course. The additional time would be needed for obtaining more practical experience and training in methods of dealing with problems that arise, and for visiting installations in order to become better qualified for operational health and safety duties.

9. In addition to attendance at lectures and carrying out practical work, candidates attending the one-year course should be required to carry out a study project in a relevant branch of the subject. This study project might be in the form of a critical examination of some relevant topic in radiological health and safety, not necessarily involving original scientific work.

OUTLINE SYLLABUS

(*Note:* Attention is particularly drawn to the sentences in italics in paragraphs 4 and 6 above).

A. *Lectures* (About one hundred lectures)

1. *Physics* (ten lectures)
   Nuclear physics and radioactivity (eight lectures)
   Interaction of radiation with matter
   Neutron physics

2. *Detection and measurement of radiation* (eleven lectures)
   Radiological units
   Radiation detectors (four lectures)
   Fundamental electronics (two lectures)
   Health physics instruments (two lectures)
   Statistics (two lectures)

3. *Radiation from machines* (five lectures)
   X-rays (four lectures)
   High energy particle accelerators

4. *Reactors* (five lectures)
   General principles of reactor design (two lectures)
   Principal types of reactors
   Safety considerations
   Uses of reactors

5. *Metallurgy* (two lectures)
   Properties of metals and materials used in atomic energy
   Effects of radiation on these metals and materials

6. *Chemistry* (five lectures)
   Radiation chemistry (two lectures)
   Tracer chemistry (two lectures)
   Chemical plant processes in the atomic energy industry

7. *Biology and radiobiology* (seven lectures)
   Cells, tissues, organs
   Anatomy and physiology
   General principles of genetics
   Principles of radiobiology
   Somatic effects of radiation
   Protection and recovery
   Genetic effects of radiation
8. *Maximum permissible doses* (four lectures)
   Basic concepts (critical organs and tissues, whole population and occupational exposure, standard man)
   Existing information on effects of exposure to radiation
   Recommendations of the International Commission on Radiological Protection for external and internal radiation
9. *Dosimetry* (five lectures)
   Theory of ionisation dosimetry (two lectures)
   Units of dose in relation to absorption of energy
   Dosimetry of X and gamma radiation, beta radiation and neutrons
   Dose calculation for internally deposited radioisotopes
10. *Natural radioactivity* (two lectures)
    Dose rate from natural sources of radiation (cosmic, gamma rays from the earth, radon in air and natural radioactivity in the body)
11. *General* (eight lectures)
    Functions of a health and safety organisation
    National and international aspects of radiological protection
    Survey of the atomic energy industry
    U.K. reactor programme
    Medical supervision of atomic energy workers
    Medical uses of radioisotopes
    Industrial and research uses of radioisotopes
    Atomic energy legislation
12. *Control of occupational radiation hazards and radioactivity* (twenty-two lectures)
    Principles of protection and control (five lectures)
    Shielding (three lectures)
    Air sampling
    Control of operations in active areas (two lectures)
    Personnel monitoring (four lectures)
    Surface finishes, decontamination (two lectures)
    Criticality (two lectures)
    Toxic hazards
    Toxicology of radioisotopes
    Pyrophoric and explosive hazards
13. *Control of environmental radiation hazards and radioactivity* (seventeen lectures)
    Radioactive aerosols; atmospheric dispersion; deposition (four lectures)
    Fission products (three lectures)
    Soil—plant—animal food chain (two lectures)
    District surveys
    Large accidental releases of radioactivity
    Waste disposal (four lectures)
    Transport of radioactive material
    Filtration of gaseous discharges

B. *Experimental work*

Experiments to include some designed to illustrate basic scientific principles, others intended to illustrate the principles of operational methods of protection.

Visits to installations to see the construction of plant and operational methods of health and safety control.

APPENDIX H

CATEGORY C

COURSES FOR SUPPORTING STAFF

1. In order to implement the recommendations regarding radiation levels and concentration of radioactivity in air and water made by authoritative bodies such as the Medical Research Council and the International Commission on Radiological Protection, it is necessary in those industries using radiation and radioactive material to employ staff to:

(a) measure and record the amount and type of radiation or radioactivity in laboratories, plant and inside and outside buildings;

(b) collect, measure and record the radioactivity of atmospheric dust samples.

In addition, such staff can carry out a standard drill when a specified level is exceeded and would immediately control access to the area affected, whilst awaiting further instructions from their supervisor.

2. Staff in this category do not normally have professional qualifications, but must be trained to use standard instruments and equipment and must have sufficient of the background of technical knowledge to carry out their duties.

3. It is suggested that lectures and demonstrations spread over about twenty sessions is a method well suited to meeting such training. The sessions could be grouped to form a full-time course for ten days, arranged to suit day release or given in the evenings, the exact arrangement being chosen to meet the convenience of employers.

4. The outline syllabus[1] below is given as a guide to the sort of course that has been run successfully. Details of courses at other centres would have to be arranged by individual technical colleges to meet the needs of local employers.

OUTLINE SYLLABUS

Structure of matter
Radioactivity
Properties and detection of radiation
The external radiation hazard (units, maximum permissible levels, instruments)
The internal radiation hazard (contamination, modes of intake, measurement)
Radioactive gases
Emergency procedure
Fission
Elementary reactor theory
Gas cooled reactors
Heavy water moderated reactors

[1] Lecture notes for a course of this nature may be obtained by those concerned with organising such courses from: Health Physics Division, Atomic Energy Research Establishment, Harwell.

APPENDIX I

BACKGROUND COURSES IN RADIOLOGICAL HEALTH AND SAFETY

1. In addition to the needs for training to meet the rapidly expanding demand for operational radiological health and safety staff, there is a wide demand throughout the country for further information on radiological problems due to the increasing use of x-rays and radioisotopes, the rapid development of the nuclear power programme, and the widespread public concern about the long term effects of nuclear weapon testing.

2. (i) Among those who should have knowledge of radiological hazards and methods of checking whether any contamination or exposure has occurred, are medical officers of health and their senior medical staff, inspectors of factories, sanitary and water engineers.

   (ii) In addition, background information should be provided, e.g., for management (including hospital management), senior staff in government departments, school medical officers, appointed factory doctors, industrial medical officers.

   (iii) Basic instruction should be given to industrial nurses, the police firemen and others in similar positions.

3. It is suggested that there should be common courses for the first two classes, suitable instruction being provided by residential courses of three days' to two weeks' duration, depending on the extent of the knowledge needed. These courses could be held at various centres, and would consist of lectures, discussion groups and study groups. In view of the wide variation in the educational background of those for whom the courses are intended, to avoid spending too much time on the more elementary parts of the subject a suitable elementary handbook should be studied beforehand by those going on the course, the content of which is given below. The courses would deal with the fundamental biological and physical sciences related to the subject and would, when necessary, be orientated to meet special needs such as for example those of medical officers of health or water engineers.

4. For the third class, it is suggested that instruction by courses provided locally, with the issue of a suitable handbook, would be adequate. For certain personnel the handbook alone might suffice.

FRAMEWORK FOR BACKGROUND COURSES

(*Note:* See paragraph 2 (i) and (ii) above.)

The length of the course and the scientific background and interest of those attending will determine the time spent on different aspects of the subject.

1. *Physical principles*

   Nature of matter. Structure of atom and fundamental particles (protons, electrons, neutrons)
   Nuclear reactions, heavy elements, nuclear fission
   Radioactivity (curie, half-life), radiations emitted (alpha, beta, gamma)
   Absorption of radiation

2. *Biological principles*
   Absorption of ionising radiations in the tissues
   Metabolism of radioactive elements
   Biological effects on cells, tissues, and organisms
   Relative biological effectiveness of the radiations

3. *Uses of nuclear energy and radiation*
   X-rays in medicine and industry
   Nature, use and operation of reactors and associated facilities
   Radioisotopes in medicine, research, agriculture and industry

4. *Radiation hazards*
   Radiation from x-rays, radium, radioisotopes in medicine and industry and from reactors, mines, particle accelerating machines, fallout, and natural sources. (ground and cosmic radiation)
   Contamination from radium, radioisotopes, reactors and mines
   Safeguarding of populations, and occupational and non-occupational workers, from the possibility of widespread radiation levels and contamination in transport, storage and waste disposal (gaseous and liquid)
   Units (rad, roentgen, rem)
   Measurement of radiation levels (counters, isonisation chambers, film badges) and personnel dosimetry
   Maximum permissible levels, concentrations and body burdens. Effects on the individual, somatic effects, genetic effects
   Medical examinations of occupational workers (pre-employment and periodic)
   Community implications and monitoring of air, water and foodstuffs

5. *Radiation protection*
   Principles (exposure time, distance, remote handling, shielding, containment)
   Materials and equipment used for protection (lead, concrete, tongs, frog-suits, dry boxes)
   Administrative controls (discipline, codes of practice for safe working and design of premises, licensing)
   Site selection for nuclear establishments
   Decontamination procedures for equipment, surfaces, clothing and skin
   Medical aspects (contaminated wounds, treatment of internal contamination, analysis of excretions, whole body monitors)
   Waste disposal
   Soil-plant-animal food chain
   Accident procedures, including implications on the community and mention of the government departments involved

6. *Functions of government departments*
   Medical Research Council—permissible levels
   Agricultural Research Council—soil-plant-food chain measurements
   Ministry of Agriculture, Fisheries and Food—waste disposal
   Ministry of Health—use of radiations and radioactive materials in medicine
   Ministry of Housing and Local Government—waste disposal
   Ministry of Labour—factory inspectorate
   Ministry of Power—licensing of reactors
   Ministry of Transport—carriage of radioactive substances and problems of nuclear powered ships

APPENDIX J

CONFERENCE ON RADIOLOGICAL HEALTH AND SAFETY

held 31st July, 1959—14th August, 1959, at New College, Oxford

Address	Sir Alexander Fleck, K.B.E., F.R.S., LL.D., D.Sc.
Opening address	Sir Douglas Veale, C.B.E., D.C.L., LL.D.
Genetic possibilities	Professor G. W. Beadle, Ph.D., D.Sc., Nobel Laureate.
Atomic and nuclear structure	R. J. Blin-Stoyle, M.A., D.Phil.
Preparation and properties of radioisotopes	D. F. Shaw, M.A., D.Phil.
Group meetings	
Demonstration: Properties of radioisotopes	P. F. D. Shaw, M.A., D.Phil.
Correlation of physical dosimetry with biological effects	R. Oliver, M.Sc., F.Inst.P., A.M.I.E.E.
Biological effects of radiation—I	R. H. Mole, M.A., B.M., B.Ch., M.R.C.P.
Biological effects of radiation—II	„ „ „ „ „ „
Biological effects of bone-seeking isotopes	Dame Janet Vaughan, D.B.E., M.A., D.M., F.R.C.P.
Discussion on bone-seeking isotopes	(Dame Janet Vaughan and R. H. Mole)
The mechanism of radiation-produced bone-marrow failure	L. G. Lajtha, M.D., D.Phil.
The fission process and nuclear reactors	G. N. Walton, M.A., F.R.I.C.
Films	
Pile-produced isotopes	R. West
The entry of fission products into human diet	R. Scott Russell, M.A., M.Sc., Ph.D.
Visit to Agricultural Research Council Laboratories and Field Station (Grove and Compton, Berks.)	
Industrial uses of radioisotopes	J. L. Putman, M.A., D.Sc., F.Inst.P.
Maximum permissible levels of radiation	E. E. Pochin, C.B.E., M.D., F.R.C.P.

Group meetings	
The control of health and safety in the Atomic Energy Authority	W. G. Marley, O.B.E., M.Sc., Ph.D.
Medical uses of radioisotopes	Professor D. W. Smithers, M.D., F.R.C.P., F.F.R.
Discussion on fall-out	(Dr. W. G. Marley, Dr. R. Scott Russell and Dr. A. C. Stevenson)
Medical supervision of personnel—I	Katharine Williams, B.Sc., M.B., B.Ch., M.R.C.P., D.I.H.
Medical supervision of personnel—II	Katharine Williams, B.Sc., M.B., B.Ch., M.R.C.P., D.I.H.
Radiation damage—protection and therapy	J. F. Loutit, C.B.E., D.M., F.R.C.P.
Visit to x-ray department, The Radcliffe Infirmary	
Group Meetings	
The Radiological Protection Service	B. E. Jones, B.Sc., A.Inst.P.
Group Meetings	
Human genetics and data	A. C. Stevenson, M.D., F.R.C.P.
Operational procedures in the Atomic Energy Authority	H. J. Dunster, B.Sc., A.R.C.S.
Visit to the Atomic Energy Research Establishment, Harwell	
Waste disposal and public health problems	H. J. Dunster, B.Sc., A.R.C.S.
Functions of government departments in the fields of radiological health and safety	R. A. Thompson, B.Sc.
"The White Queen"	Sir Ernest Rock Carling, F.R.C.S., F.R.C.P., F.F.R., LL.D.
Address	Sir Charles Darwin, K.B.E., M.C., F.R.S., Sc.D.

Final discussion, summing up, and conclusion.

APPENDIX K

UNITED KINGDOM ATOMIC ENERGY AUTHORITY FILM CATALOGUE

CALDER HALL AND CHAPELCROSS

Great Day — *Great Britain* 1956

16/35 mm. Sound. Eastman colour. 20 mins.
Produced by Ace Film Productions for U.K.A.E.A.
Available (free) from: (as for Construction of Calder Hall)

The Royal Opening of Calder Hall nuclear power station. The film includes shots of construction and an animated sequence explaining its working (*How a Thermal Reactor Works*, q.v.). It is suitable for non-technical audiences.

How a Thermal Reactor Works — *Great Britain* 1956

16/35 mm. Sound. Eastman colour. 7 mins.
Produced by Ace Film Productions for U.K.A.E.A.
Available from: (as for Construction of Calder Hall)

The animated section of "*Great Day*" (q.v.) showing how a thermal reactor works.

The building of Calder Hall nuclear power station and the fast breeder reactor at Dounreay (q.v.) presented problems of construction which had never had to be tackled before. Cameramen have filmed every important stage in the construction and the following films have been made to help meet the Atomic Energy Authority's commitment to train British industry in the techniques of building nuclear reactors for power production and to show engineers what is being done in this new field. Films have also been made on the operation of a Calder Hall type reactor.

The Construction of Calder Hall — *Great Britain* 1957

16/35 mm. Sound. B/W. 40 mins.
Produced by Ace Film Productions for U.K.A.E.A.
Available (free) from: Public Relations Section, U.K.A.E.A., Risley, Warrington, Lancs.
Public Relations Branch, U.K.A.E.A., 11, Charles II Street, London, S.W.1.
Central Film Library, Bromyard Avenue, W.3.
Ace Distributors Ltd., 14, Broadwick Street, London, W.1.

The civil engineering techniques involved in building a nuclear power station. Operations shown include preparation of the site and placing the concrete for the foundations of the reactor building; placing in position of the 8 ft. thick concrete roof; laboratory tests on site to ensure that the concrete conforms to the requisite high standard; and the accurate placing of the concrete round the many charge tubes and ducts.

Engineering at Calder Hall — *Great Britain* 1957

16/35 mm. Sound. B/W. 38 mins.
Produced by Ace Film Productions for U.K.A.E.A.
Available (free) from: (as for *Construction of Calder Hall*)

The building of the pressure vessel at the Calder Hall nuclear power station. The film shows the use of a guy derrick, 200 ft. high, to lift the sections and lower them into position inside the building; welding operations both manual and automatic; and the accurate cutting of the holes for the charge tube stubs, with the associated assembly and welding techniques. In conclusion the film shows how the vessel was stress relieved and the subsequent tests, lagging and preparations for installing the graphite core.

Heat Exchangers at Calder Hall — *Great Britain* 1957

16/35 mm. Sound. B/W. 28 mins.
Produced by Ace Film Productions for U.K.A.E.A.
Available (free) from: (as for *Construction of Calder Hall*)

A detailed record of the production and installation of the first heat exchanger for the Calder Hall nuclear power station. The operations shown include fabrication of sections at the manufacturer's works, the transport of the sections by road; welding; lifting of the 200 ton shells from the horizontal to the vertical and their positioning on the tables; insertion of the banks of boiler tubes into the shell; and the precautions taken to prevent contamination of the reactor circuit. Animated diagrams are used to show how the coolant gas circulates between the pressure vessel and the heat exchangers.

Reactors at Calder Hall — *Great Britain* 1958

16/35 mm. Sound. B/W. 35 mins.
Produced by Ace Film Productions for U.K.A.E.A.
Available (free) from: (as for *Chapelcross*)

All the work carried out inside the reactor pressure vessel, including cleaning, graphite laying and the installation of gas sampling equipment.

Operating a Calder Hall Type Reactor

Three films have been produced primarily for instructional purposes for nuclear power station operators.

(1) *Full Power* — *Great Britain* 1959
16/35 mm. Sound. Colour. 20 mins.

This film describes the operation of Calder Hall type reactors under normal conditions for the production of electricity.

(2) *Refuelling* — *Great Britain* 1959
16/35 mm. Sound. Colour. 32 mins.

This film describes the operations involved in the discharge of fuel and its replacement by new fuel elements in Calder Hall type reactors.

(3) *Starting Up* — *Great Britain* 1959
16/35 mm. Sound. Colour.

This film describes the procedure required in the starting up of Calder Hall type reactors after shut down. The film is in the final stages of production.

All three were produced by Ace Film Productions for U.K.A.E.A.
Available (free) from: (as for *Chapelcross*)

Chapelcross *Great Britain* 1959

16/35 mm. Sound. Eastman Colour. 20 mins.

Produced by Ace Film Productions for U.K.A.E.A.

Available (free) from: Public Relations Section, U.K.A.E.A., Risley, Warrington, Lancs.

Public Relations Branch, U.K.A.E.A., 11, Charles II Street, London, S.W.1.

Ace Distributors Ltd., 14, Broadwick Street, London, W.1.

A film suitable for non-technical audiences showing some important features of the construction of Chapelcross nuclear power station, the first to be built in Scotland. It also includes scenes of the official opening ceremony.

DOUNREAY

The building of Calder Hall (q.v.) nuclear power station and the fast breeder reactor at Dounreay presented problems of construction which had never had to be tackled before. Cameramen have filmed every important stage in the construction and the following films have been made to help in meeting the Atomic Energy Authority's commitment to train British industry in the techniques of building nuclear reactors for power production and to show engineers what is being done in this new field.

The Dounreay Sphere *Great Britain*

16/35 mm. Sound. B/W. 35 mins.

Produced by Ace Film Productions for U.K.A.E.A.

Available (free) from: (as for *Construction of Calder Hall*)

A record of the construction of the sphere for the fast breeder reactor at Dounreay in the north of Scotland and of the unusual problems which had to be solved. This steel sphere, 135 feet in diameter, is the largest ever built in Europe.

The Dounreay Project *Greot Britain* 1959

16/35 mm. Sound. B/W. 23 mins.

Produced by Ace Film Productions for U.K.A.E.A.

Available (free) from: (as for *Chapelcross*)

A survey of the work involved in providing the various buildings at Dounreay other than the fast reactor itself. It includes the construction of an undersea tunnel for waste disposal, a sea water channel to the pumphouse and laboratory and other buildings.

The Dounreay Fast Reactor *Great Britain* 1959

16/35 mm. Sound. B/W. 38 mins.

Produced by Ace Film Productions for U.K.A.E.A.

Available (free) from: (as for *Chopelcross*)

A detailed record showing the construction of the Dounreay fast breeder reactor covering the fabrication and installation of the coolant circuits, the reactor vessel and core.

Criticality *Great Britain*

16/35 mm. Sound. Eastman colour. 22 mins.

Produced by G. Buckland Smith in association with the Film Producers Guild for U.K.A.E.A.

Available (free) from: Public Relations Branch, U.K.A.E.A., 11 Charles II Street, London, S.W.1.
Central Film Library, Bromyard Avenue, London, W.3.

The film describes the conditions which produce criticality and the methods used for controlling them. It was made primarily for the training in safety precautions for industrial workers in atomic energy factories and includes animated sequences.

BEPO Wigner Energy Release *Great Britain* 1958

16/35 mm. Sound. B/W. 14 mins.
Produced by the A.E.R.E. Film Unit, Harwell.
Available (free) from: A.E.R.E. Film Unit, Harwell.

Preparations and procedure when releasing Wigner energy in a graphite moderated pile (BEPO 1958).

Exercise Mermaid *Great Britain* 1957

16/35 mm. Sound. B/W. 15 mins.
Produced by the A.E.R.E. Film Unit, Harwell.
Available (free) from: A.E.R.E. Film Unit, Harwell.

Survey teams from Harwell carrying out investigations into the dispersal of radioactive substances off the Dorset coast in preparation for the laying of a pipeline from the Atomic Energy Establishment at Winfrith. Emphasis on safety of local fishing industries and shore contamination.

Loop Disposal *Great Britain* 1957

35 mm. Silent. B/W. 20 mins.
Produced by the A.E.R.E. Film Unit, Harwell.
Available (free) from: A.E.R.E. Film Unit, Harwell.

This film is a record of the apparatus used and the technique adopted to cut up the Mk. I loop from BEPO.

A Matter of Contamination Sense *Great Britain* 1958

16/35 mm. Sound. B/W. 10 mins.

Produced by G. Buckland Smith in association with the Film Producers Guild for U.K..A.E.A.

Available (free) (only to organisations directly concerned with atomic energy) from: Public Relations Branch, U.K.A.E.A., 11, Charles II Street, London, S.W.1.

This film shows the hazards of handling radioactive substances and emphasises the importance of understanding the principles on which contamination drills are based. Made specially for workers in nuclear energy establishments.

Metals of the Nuclear Age — *Great Britain* 1958

16/35 mm. Sound. Eastman colour. 34 mins.

Produced by G. Buckland Smith in association with the Film Producers Guild for U.K.A.E.A.

Available (free) from: Public Relations Branch, U.K.A.E.A., 11, Charles II Street, London, S.W.1.

The film gives an account of some of the important problems involved in developing special metals for nuclear use.

More Power from the Atom — *Great Britain* 1958

16/35 mm. Sound. Eastman colour. 25 mins.

Produced by Ace Film Productions for U.K.A.E.A.

Available (free) from: Public Relations Branch, U.K.A.E.A., 11, Charles II Street, London, S.W.1.
Public Relations Section, U.K.A.E.A., Risley, Warrington, Lancs.
Ace Distributors Ltd., 14, Broadwick Street, London, W.1.

This film carries the story of nuclear power in Britain forward from the completion of Calder Hall. It includes construction work at the power stations being built for the electricity authorities and work on more advanced reactors in the A.E.A. There is also a section dealing with ZETA, the thermonuclear assembly at Harwell.

Personnel Protection in Toxic Areas — *Great Britain* 1956

16/35 mm. Sound. B/W. 30 mins.

Produced by the A.E.R.E. Film Unit, Harwell.

Available (free) from: A.E.R.E. Film Unit, Harwell.

Precautions for people working in active areas. The film includes dressing, working, removing active waste and suit treatment.

Principles of Nuclear Fission — *Great Britain* 1958

16 mm. Sound. Eastman colour. 10 mins.

Produced by G. Buckland Smith in association with the Film Producers Guild and the Educational Foundation for Visual Aids for U.K.A.E.A.

Available from Foundation Film Library, Brooklands House, Weybridge, Surrey. (hire).

The animated section from "*Criticality*" (q.v.) showing the structures of the atom, the principles of nuclear fission and of a chain reaction.

Radioisotopes in Industry — *Great Britain* 1958

16/35 mm. Sound. Eastman colour. 25 mins.

Produced by G. Buckland Smith in association with the Film Producers Guild for U.K.A.E.A.

Available (free) from: Public Relations Branch, U.K.A.E.A., 11, Charles II Street London, S.W.1.

The film describes the nature of radioactive isotopes and the many uses to which they can be put in industry, for the analysis of continuous flow processes, for accurate measurement of minute quantities, for radiography and for their effects upon chemical reactions.

Spraypak — *Great Britain* 1956

16 mm. Silent. B/W. 12 mins.
Produced by the A.E.R.E. Film Unit, Harwell.
Available (free) from: A.E.R E Film Unit, Harwell

Operating data on vertical and horizontal packing used in heavy water plant.

Pituitary Implantation with Au^{198}

16 mm. Sound. B/W. 10 mins.
Produced by the A.E.R.E. Film Unit, Harwell.

Available (free) from: A.E.R.E. Film Unit, Harwell.

Method of destroying pituitary gland by implanting grains of radioactive gold or of yttrium. Demonstration by means of a dummy model.

Atomic Achievement — *Great Britain* 1956

16/35 mm. Sound. Eastman Colour. 20 mins.
Produced by Rayant Films.
Available from Central Office of Information

First decade of British atomic energy work.

New Tool for Industry — *Great Britain* 1955

16 mm. Sound. B/W. 20 mins.
Produced by the A.E.R.E. Film Unit, Harwell.
Available from Central Office of Information.

Some typical radioisotope uses in industry.

Atoms in Industry — *Great Britain* 1955

16/35 mm. Sound. B/W. 14 mins.
Produced by Central Office of Information
Available from: Central Office of Information.

Discussion on development of peaceful uses of atomic energy.

The Central Office of Information Film Library (Government Buildings, Bromyard Avenue, Acton, London, W.3.) supplies those films listed as available from C.O.I., on hire at a modest rental. The hire rates on 10th December 1959 were:

Type of Film	*First Day*	*Each Subsequent Day*
16 mm. black and white	5/- per reel	1/- per reel
16 mm. sound/colour	10/- ,, ,,	2/- ,, ,,
35 mm. black and white	12/- ,, ,,	3/- ,, ,,
35 mm. colour	16/- ,, ,,	4/- ,, ,,

These rates should be confirmed with the C.O.I. at the time of hiring; one reel is equivalent to about 10 minutes running time.

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